FIRM-LEVEL DISCUSSION OF BIODIVERSITY RISK IN THREE HIGHLY EXPOSED INDUSTRIES

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ABSTRACT

Global economic activity depends on, and has impacts on, biodiversity. As such, biodiversity loss poses physical and transition risks at the firm, industry and economy levels. This paper explores how individual firms discuss biodiversity-related risks. I identify six highly valued firms in three highly exposed industries: Diamondback Energy and Antero Resources (Oil & Gas); Alcoa and Warrior Met Coal (Metals & Mining); and Archer-Daniels-Midland and Bunge Global SA (Agricultural Products). By conducting textual analysis of the firms' most recent financial disclosures (2023 10-Ks) and sustainability reports, I find that firms predominantly frame biodiversity risks in terms of regulatory challenges rather than material threats. Oil & Gas firms focus on risks associated with species protection laws and wetland regulations. Metals & Mining firms highlight permitting constraints associated with forest and species protection. Agricultural firms acknowledge both regulatory and reputational risks, particularly stemming from EU anti-deforestation regulation. Across industries, discussions of biodiversity risk are largely reactive, with little evidence of proactive mitigation strategies beyond regulatory compliance.

INTRODUCTION

Biodiversity describes the variety of life on Earth: from genes, to bacteria, to animals and plants, to entire ecosystems such as forests and coral reefs (United Nations, n.d.). Human societies have always relied on biodiversity (Díaz, Fargione, Chapin III, & Tilman, 2006). The term *ecosystem services* encompasses all benefits that ecosystems provide to humans: *provisioning services* like food and fibre; *regulating services* such as pollination; *supporting services* like the maintenance of genetic diversity; or *cultural services* such as opportunities for recreation or spiritualty (USDA Climate Hubs, n.d.).

Despite the importance and irreplaceability of ecosystem services for human life, human activity has driven an accelerated loss of biodiversity via land use change, overexploitation, environmental pollution and more (The Royal Society, n.d.). Estimates suggest that the current global rate of species extinction is tens to hundreds of times higher than the average rate over the past 10 million years – and is accelerating (IPBES, 2019). It follows that loss of biodiversity poses significant threats to humans (Cardinale, et al., 2012). Although climate change and its impact on human life has dominated headlines in recent years, biodiversity loss has also received attention. One headline even states that *Loss of biodiversity is just as catastrophic as climate change* (Watson, 2021).

Amidst ongoing work on the impact of biodiversity loss on human life at large, some scholars are considering the interactions between biodiversity and economic activity. Many examine the impact of business activities on biodiversity, such as Kurth, Wübbels, Portafaix, Felde, & Zielcke (2021), Finance for Biodiversity Foundation (2023), and Panwar, Ober, & Pinkse (2022). Others have focused on the importance of biodiversity to the economy and businesses. For example, the Dasgupta Review (2021) argues that nature must be recognised as "our most precious asset"; that humanity has collectively mismanaged its "global portfolio"; and that nature's value must be incorporated into economic decision making. Indeed, research suggests that $44 trillion of economic value generation—more than half of the world's total GDP—is moderately or highly dependent on ecosystem services and is therefore exposed to risk from nature loss (World Economic Forum and PwC, 2022).

Looking holistically, the ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure) partnership between the United Nations Environment Programme and Global Canopy[1] maintains an online tool allowing users to explore exposures of different industries to nature-related risk (ENCORE, n.d.). This partnership has also published reports, case studies and guides to assist in the navigation of these risks. Their 2020 report *Beyond Business As Usual: Biodiversity Targets and Finance* has been highly informative to the work in the present paper (UN Environment Programme, 2020).

We have seen evidence that business depends on biodiversity, that business impacts biodiversity, and that Earth is experiencing an unprecedented rate of biodiversity loss. It follows that the economy, specific industries, and individual firms, are exposed to risk from biodiversity loss. These risks may be physical: biodiversity loss may cause direct, tangible damage to business operations. On the other hand, transition risks[2] may arise as governments and other actors seek to reduce biodiversity loss. Intuitively, firms and industries that are highly dependent on ecosystem services would be most exposed to physical risks. On the other hand, firms and industries that have the most negative impacts on biodiversity would be the most exposed to transition risks. This logic is reiterated in Giglio, et al. (2024) and the UN Environment Programme (2020).

Despite industries' and firms' exposure to biodiversity risk, there has until recently been little scholarship on the subject. In 2023 a call was made for more research into the nature and pricing of financial risks related to biodiversity loss (Karolyi & Tobin-de la Puente, 2023). Answering this call, Giglio, Kuchler, Stroebel and Zeng develop several measures to quantify biodiversity risk at the economy, industry, and firm levels in a paper entitled *Biodiversity Risk*
(2024). These metrics use manual and computational methods and draw from diverse sources: news articles; the holdings of biodiversity-related funds; firms' responses to a questionnaire fielded by the Carbon Disclosure Project; a survey of 668 finance professionals, regulators, and academics; and textual analyses of firms' 10-K statements.[3] The authors' findings from applying the industry and firm-level metrics are most relevant to the present paper.

[1] Previously known as The Natural Capital Finance Alliance (NCFA).
[2] I.e. regulatory, legal, market and reputational risks.
[3] A 10-K statement is a comprehensive report filed annually by publicly listed companies with the US Securities and Exchange Commission (SEC). It provides a detailed overview of a company's performance. It includes sections on the company's operations, risk factors, management discussion, and financial statements (Kenton (author), Scott (reviewer), & Kvilhaug (fact checker), 2024).

At the industry level the authors find the top five industries most exposed to biodiversity risk to be: Energy; Utilities; Food, Beverage & Tobacco; Pharmaceuticals, Biotechnology & Life Sciences; and Materials.[4] At the firm level, they find that 4.2% of 10-K statements in their sample mention biodiversity between 2015 and 2023; 27.6% of the 10-Ks that mention biodiversity do so in a predominantly negative way (i.e. pertaining to risk rather than opportunity); and 75.5% of all 10-Ks that mention biodiversity discuss biodiversity-related regulation risks. At the time of writing, the authors maintain a plot showing the share of 10-Ks that mention biodiversity risk, by year and by industry, on the paper's website (Industry Exposures, n.d.). The authors also make steps to categorise the biodiversity risks discussed into physical risks and transition risks. Due to the task's complexity and mixed results of the Large Language Model (ChatGPT)-based methodology, the results are ultimately left out of the scope of the final paper and confined to the appendices.

Giglio, et al.'s findings demonstrate that some firms are discussing biodiversity risk, including regulatory risk, in their 10-K statements. So, the next question becomes: *how* are these firms discussing biodiversity risk? For example, which biodiversity-related regulations presents risks? What are the expected impacts? Do firms in nature-dependent industries discuss physical risk, and firms in industries with a significant impact on biodiversity discuss transition risk?

These are the questions that the present work seeks to answer. This work provides case studies of the respective 10-Ks of six high-value firms operating within three industries that are highly exposed to biodiversity risk. [5] It seeks to deepen readers' understanding of firm-level biodiversity risk through these six illustrative examples, including quotes and brief analyses.

This paper focuses more on risk recognition than risk mitigation. Nevertheless, it will touch on the latter. It holds as a principle that reducing (or reporting efforts to reduce) impacts *on* biodiversity loss is a strategy for reducing risks *from* biodiversity loss. This is most obvious for physical risks, but also holds for transition risks. For example, if an industry or firm is perceived to be doing less damage to biodiversity, there is less impetus for regulation to alter their activities or require remediation. Equally, reputation risks from negatively impacting biodiversity are minimised if their perceived negative impacts are fewer or smaller.

METHODOLOGY

SELECTION OF INDUSTRIES

I selected three target industries by first mapping the UN Environment Programme's (2020) nine "sub-industries" most likely exposed to biodiversity risk to Giglio, et al.'s (2024) five "industries" most exposed to biodiversity risk. Inconsistencies between (and within) each paper's terminology, and the most recent update to the GICS taxonomy (MSCI, 2024) allowed for pragmatic interpretation of *sector*, *industry* and *sub-industry*.[6] I eliminated all industries

[4] By taking an average of their seven proposed metrics.
[5] By Giglio, et al. (2024) and the UN Environment Programme (2020).
[6] The GICS (Global Industry Classification Standard) is a taxonomy for classifying companies into sectors, industry groups, industries and sub-industries. It was developed by Morgan Stanley Capital International and Standard & Poor **No source specified.**. The standard has changed over time. What is more, human natural language use is flexible. As such, the use of the words *sector*, *industry*, *sub-industry* can be inconsistent between and within sources. Both the UN Environment Programme (2020) and Giglio, et al. (2024) utilise GICS. However, what Giglio, et al. call *industries* (and occasionally *sectors*) have 4-digit GICS codes. They are named *sectors* in

which were not common to the two sources. I further narrowed the remaining list according to my personal curiosity. Appendix 5 contains the complete mapping of the two sources' lists and my final selections: Oil & Gas, Metals & Mining, and Agricultural Products. In the most recent GICS mapping, Oil & Gas (GICS code 101020) and Metals & Mining (151040) are *industries*, and Agricultural Products (30202010) is a *sub-industry* (MSCI, 2024). For simplicity, this paper will tend to call all three *industries*.

SELECTION OF FIRMS

This paper is intended to illustrate the findings of Giglio, et al. in *Biodiversity Risk* (2024). Therefore, I selected firms from the publicly available dataset associated with this paper (Download Data, 2024). Additionally, I obtained a linking table to these firms' GICS classifications from one of the authors, Xuran Zeng. The data in this linking table originated from Wharton Research Data Services' (WRDS) Compustat database.

I used the Pandas library in Python, in a Jupyter notebook via Google Colab, to:

1. Filter the data to find firms that (a) belonged to the respective target industries and (b) mentioned biodiversity in their 2023 10-K filing.
2. Call the Yahoo Finance API to assign each firm's current market capitalisation.
3. Choose the top two highest-market-value firms in each industry.

After following these steps, I found that the dataset only included one Agricultural Products firm, whose 10-K biodiversity scores reflected no mention of biodiversity.[7] Therefore, I repeated Steps 1-3 on the WRDS Compustat data, modifying Step 1 to include GICS code but exclude biodiversity scores.

As a result of this process, my final firm selections were:

- Diamondback Energy and Antero Resources (in the Oil & Gas industry)
- Alcoa and Warrior Met Coal (in the Metals & Mining industry)
- Archer-Daniels-Midland and Bunge Global SA (in the Agricultural Products industry).

Screenshots of the three industries' respective firms, in order of market capitalisation, are available in Appendix 6. The full dataset and accompanying Jupyter notebook are available upon request.

INVESTIGATION OF FIRM-LEVEL BIODIVERSITY RISK

Given this paper's intention to illustrate the findings of Giglio, et al.'s paper *Biodiversity Risk* (2024), for my substantive analysis I employed another of their methodological tools: the biodiversity dictionary. The dictionary that I used is from the May 2023 version of their paper, *Biodiversity Risk* (Giglio, Kuchler, Stroebel, & Zeng, 2023).[8]

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the most recent GICS mapping. What the UN Environment Programme calls *sub-industries* largely have 6-digit GICS codes. They are named *industries* in the most recent GICS mapping, with some 8-digit sub-industry exceptions. It is outside the scope of the present work to get bogged down in semantics. Therefore, I ask that the reader take a pragmatic approach when reading terminology.

[7] I believe this to be an error. Further investigation of this potential error is beyond the scope of this paper.

[8] In the most recent (2024) version of *Biodiversity Risk*, the authors expand this dictionary to 100 terms.

The biodiversity dictionary comprises 20 terms:

- biodiversity
- ecosystem(s)
- ecology (ecological)
- habitat(s)
- species
- (rain)forest(s)
- deforestation
- fauna
- flora
- marine
- tropical
- freshwater
- wetland
- wildlife
- coral
- aquatic
- desertification
- carbon sink(s)
- ecosphere
- biosphere

I conducted simple text searches for the biodiversity dictionary's terms in the 2023 10-Ks of the six target companies. I then used my own comprehension to analyse the passages in which these terms appeared. The goal of this paper is to provide human readers with insight into how firms are considering biodiversity risk. Human intelligence appeared to be the most appropriate tool to generate this insight.

Throughout this paper, in quotes from firms' 10-Ks, terms from the biodiversity dictionary will be **bold and underlined**.

A full mapping of which terms appeared in each firm's 10-K, plus whether they were mentioned in the context of physical or transition risks, can be found in Appendix 1.

OIL & GAS

By Giglio, et al.'s (2024) metrics, Energy earns the highest average biodiversity risk score out of the 24 sectors analysed. Meanwhile, the UN Environment Programme (2020) names both Oil & Gas Exploration & Production, and Oil & Gas Storage & Transportation (which falls under Energy), within its nine priority industries most likely exposed to biodiversity risk.

Oil and gas extraction negatively affects biodiversity through the conversion, degradation, pollution, and disturbance of habitats (Beckmann, Murray, Seidler, & Berger, 2012). Harfoot, et al. (2018) find that "present oil and gas infrastructure occurred at locations with substantially higher species richness and range rarity than locations where no exploitation was taking place". That is, geographical areas where oil and gas are extracted tend to be highly biodiverse, including many endemic species that are found only in those locations. Therefore, the magnitude of this industry's impact is heightened by its site locations, in addition to the nature of its operations.

As Giglio, et al. (2024) point out, this high biodiversity impact likely translates to high transition risk as regulation seeks to mitigate biodiversity loss. Indeed, their ongoing firm-level analysis shows that out of 24 industries, Energy has the highest proportion of 10-K statements mentioning biodiversity. This has been true every year since 2017. By 2023, 40% of Energy firms' 10-Ks mention biodiversity, compared to the next-highest sector (Utilities) at just 24% (Industry Exposures, n.d.). Two of the firms mentioning biodiversity in their 10-Ks are Diamondback Energy and Antero Resources.

DIAMONDBACK ENERGY, INC

Diamondback Energy is an independent oil and natural gas company focused on the acquisition, development, exploration and exploitation of oil and natural gas reserves. It is headquartered in Midland, Texas. As of January 31, 2025, its market capitalisation is $48.6 billion (Yahoo Finance, 2025) and it is ranked as 499 in the Fortune 500 (Fortune, 2024). Diamondback operates primarily in the Wolfberry Trend, an area of the Permian Basin in West Texas and the Trans-Pecos region (Diamondback Energy, n.d.).

The Trans-Pecos region hosts both mountain and desert habitats, allowing for great vegetation and wildlife diversity (Texas Parks & Wildlife, n.d.). As biodiversity and wildlife conversation organisations point out, the Permian Basin is home to three of the United States' most endangered animals: lesser prairie chickens, dunes sagebrush lizards, and Texas hornshell mussels (Center for Biological Diversity, n.d.).

Diamondback's 2023 10-K (Diamondback Energy, Inc., 2024) mentions transition risks relating to biodiversity loss in three primary ways: relating broadly to environmental matters; in terms of water discharges and wetlands; and relating to species endangerment.

ENVIRONMENTAL MATTERS

Under Items 1 and 2. Business and Properties → Regulation → Environmental Matters, Diamondback Energy say:

> "Our oil and natural gas exploration, development and production operations are subject to stringent laws and regulations governing the discharge of materials into the environment or otherwise relating to environmental protection. These laws and regulations may require the acquisition of a permit before drilling commences, restrict the types, quantities and concentrations of various substances that can be released into the environment in connection with drilling and production activities, limit or prohibit construction or drilling activities on certain lands lying within wilderness, **wetlands**, **ecologically** or seismically sensitive areas, and other protected areas, require action to prevent or remediate pollution from current or former operations, such as plugging abandoned wells or closing pits, result in the suspension or revocation of necessary permits, licenses and authorizations, require that additional pollution controls be installed and impose substantial liabilities for pollution resulting from our operations or related to our owned or operated facilities. Liability under such laws and regulations is often strict (i.e., no showing of "fault" is required) and can be joint and several.
>
> […]
>
> Changes in environmental laws and regulations occur frequently, and any changes that result in more stringent and costly pollution control or waste handling, storage, transport, disposal or cleanup requirements could materially and adversely affect our operations and financial position, as well as the oil and natural gas industry in general. Our management believes that we are in substantial compliance with applicable environmental laws and regulations and we have not experienced any material adverse effect from compliance with these environmental requirements. This trend, however, may not continue in the future."

Diamondback's mention of the risk from biodiversity loss is certainly transitional in nature – it concerns only regulation. It is also generic, including regulation seeking to reduce biodiversity loss under the broader umbrella of environmental regulation. Their concerns about the impacts of these regulations could be summarised as: delays, restrictions or prohibitions of (aspects of) operations, and the requirement to take additional preventative or restorative measures. These effects could lead to substantial liability and ultimately impact the company's operations or finances. Their specific mention of the frequent *changes* in environmental regulations may imply that changes in biodiversity – e.g. a particular species or habitat becoming more endangered – could lead to *new* regulations. However, they make no mention of a specific regulation or any current infringements and assign no specific value to these potential future risks.

WETLANDS

More substantial is Diamondback's discussion of wetlands. Wetlands are an important topic in biodiversity discussions. "Wetlands have been called 'biological super systems' […]. In terms of number and variety of species supported, they are as rich as rainforests and coral reefs" (The Wetlands Initiative, n.d.). The Ramsar Convention on Wetlands (2021) states that about 40% of the world's plant and animal species depend on wetlands, including 30% of all known fish species.

Diamondback's specific discussion of wetlands falls under Items 1 and 2. Business and Properties → Regulation → Environmental Matters → Water Discharges. It describes that The Federal Water Pollution Control Act of 1972 (also known as the Clean Water Act or CWA) prohibits the discharge of pollutants, dredge and fill materials into regulated waters unless authorized by a permit issued by the Environmental Protection Agency (EPA) or the state. The complication is that:

> "The scope of waters regulated under the CWA has fluctuated in recent years."

On numerous occasions since 2015 (namely 2015, 2019, 2021, 2023), the scope of regulated waters has fluctuated, sometimes unclearly, to include and exclude wetlands. Diamondback's 2023 10-K provides an overview of this history. As explained by McAiley (2024), "waters" in the Clean Water Act generally refer to "bodies of open water", and wetlands "must be indistinguishably part of a body of water that itself constitutes 'waters' under the CWA." The crux of the ongoing debate is the definition of "indistinguishably part of". Most recently (May 2023), the Supreme Court issued an opinion that has been widely interpreted to exclude most wetlands from being regulated by the CWA. In September 2023, the EPA and the US Army Corps of Engineers (the Corps) published a final rule:

> "These recent actions have provided some clarity. However, to the extent the EPA and the Corps broadly interpret their jurisdiction and expand the range of properties subject to the CWA's jurisdiction, we or third-party operators could face increased costs and delays with respect to obtaining permits for dredge and fill activities in **wetland** areas."

So, the transition risk that Diamondback describes here pertains to a risk from new interpretation of *existing* regulation. As they rightly state, this decision lies with the EPA and the Corps. Diamondback do not elaborate on these potential "increased costs and delays".

ENDANGERED SPECIES

The final way in which Diamondback's 10-K discusses biodiversity risk also concerns transition risk. It is linked to endangered species. This discussion takes place in two locations. First is under Items 1 and 2. Business and Properties → Regulation → Environmental Matters → Endangered Species:

> "The federal Endangered **Species** Act, or ESA, and analogous state laws restrict activities that may affect listed endangered or threatened **species** or their **habitats**. If endangered species, such as the recently listed lesser prairie chicken, are located in areas where we operate, our operations or any work performed related to them could be prohibited or delayed or expensive mitigation may be required. While some of our operations may be located in areas that are designated as **habitats** for endangered or threatened **species**, we believe that we are in compliance with the ESA. However, the designation of previously unprotected **species**, such as the dunes sagebrush lizard (proposed as endangered on July 3, 2023), in areas where we operate as threatened or endangered could result in the imposition of restrictions on our operations and consequently have a material adverse effect on our business."

The discussion is somewhat more tangible than the previous mentions of general environmental regulation and wetland-related regulation. Interestingly, in this one paragraph Diamondback highlights two of the three endangered Permian Basin species for which biodiversity and wildlife protection organisations have been advocating (Center for Biological Diversity, n.d.).

There is a distinction drawn here between two similar but subtly different risks. On one hand, the risk that endangered or threatened species could be *found* in areas where they currently operate. In this case, existing operations could be prohibited, delayed or require expensive mitigation. On the other hand, the risk that species (that they are potentially already aware of) living in their areas of operation may be *newly designated* as endangered. For example, the dunes sagebrush lizard mentioned is endemic to the area where Diamondback operates – it only exists in the Permian Basin (Ullenberg, 2024). As of this 2023 10-K, Diamondback believed that they were in compliance with the ESA. However, in June 2024, the dunes sagebrush lizard was added to the endangered species list (Fish and Wildlife Service, 2024). As such, when Diamondback file their 10-K for fiscal year 2024, interested readers should note whether the potential "material adverse effect" on their business has been realised.

Diamondback's 2023 10-K repeats the same concerns about species protection regulations again in Item 1A. Risk Factors:

> "Restrictions on drilling activities intended to protect certain species of **wildlife** may adversely affect our ability to conduct drilling activities in some of the areas where we operate".

Additionally, it highlights that:

> "Seasonal restrictions [associated with wildlife protection] may limit our ability to operate in protected areas and can intensify competition for drilling rigs, oilfield equipment, services, supplies and qualified personnel, which may lead to periodic shortages when drilling is allowed. These constraints and the resulting shortages or high costs could delay our operations and materially increase our operating and capital costs."

The seasonal nature of some restrictions, and resulting competition for operational components in unrestricted periods, adds an additional dimension to regulatory compliance risk. However, Diamondback does not highlight any specific occurrences of these seasonal wildlife protection restrictions.

It is also worth noting that in their Corporate Sustainability Report for 2024, Diamondback recognises the SASB[9] Biodiversity Accounting Metric of *Percentage of (1) proved and (2) probable reserves in or near sites with protected conservation status or endangered species habitat* (Diamondback Energy, 2024). However, these figures are "*not disclosed*". We can only speculate as to why. It will be interesting to see if the company begins reporting on this measure in future.

MITIGATION

Diamondback's 2024 Corporate Sustainability Report (Diamondback Energy, 2024) gives some insight into their risk mitigation strategies. Throughout (in the context of *all* business risk), they mention the Enterprise Risk Management (ERM) system overseen by their Board of Directors. The only specific mention of mitigating biodiversity risk comes under Environment → Land Use & Biodiversity → Endangered species:

> "We systematically assess for endangered **species** before moving into a new area. Our policy is to avoid operating where there are known threatened or endangered **species**. If protected **species** or **habitats** are identified, we will utilize a third-party expert to mitigate impacts of our operations. In 2021, Diamondback enrolled in a Candidate Conservation Agreement with Assurances (CCAA) through the U.S. Fish & Wildlife Service in order to ensure the protection of the Dunes Sagebrush Lizard. […] The CCAA is completely voluntary and will ensure preservation of the **species** on shared land with oil and gas production."

As per their 2023 10-K, Diamondback are aware of transition risks related to existing or newly classified endangered species living in their areas of operation. Avoiding new operations in areas that are home to endangered species, and working with third parties to mitigate impacts on protected species or habitats, are both strategies to mitigate these risks.

Regarding one particular species, this CSR report covers 2024, *after* the dunes sagebrush lizard was added to the endangered species list. This outcome was highlighted in Diamondback's 2023 10-K, as a potential source of risk. Their entry into a voluntary Candidate Conservation Agreement with Assurances (CCAA) for the protection of this species could be seen as proactive risk mitigation. That is, having a formal (yet voluntary) agreement to protect the species while continuing operations could reduce the perceived need for those operations to be restricted.

ANTERO RESOURCES

Founded in 2002, Antero Resources is an independent oil and gas company that acquires, explores, develops, and produces natural gas, natural gas liquids and oil. It is headquartered in

[9] Sustainability Accounting Standards Board

Denver, Colorado. As of January 31, 2025, it has a market capitalisation of $11.70 billion (Yahoo Finance, 2025).

Antero's reserves are entirely in the Appalachian Basin, in the Marcellus and the Utica shales (Antero Resources, 2025). Several studies exist on the impact of hydraulic fracturing[10] on these biodiversity-rich shales. For example, Kiviat (2013) and Farwell, Wood, Dettmers, & Brittingham (2020). In their 2023 Environmental, Social and Governance report, Antero report that 44% of their proved reserves are in or near sites with protected conservation status or endangered species habitat (Antero Resources, 2024).

Mirroring Diamondback Energy, Antero Resources also focus on transition risk when it comes to biodiversity. They do so in the same three ways: in relation to general environmental protection regulation; water discharges and wetlands; and endangered species (Antero Resources Corporation, 2024). That said, Antero make one potential reference to physical *dependence* – if not *risk* – in their Biodiversity Policy. They say "we are keenly aware that we depend on **biodiversity** and the stability of the environment for the continued prosperity of our business" (Antero Resources Corporation, 2023).

ENVIRONMENTAL MATTERS

Under Items 1 and 2. Business and Properties → Regulation of Environmental and Occupational Safety and Health Matters → General, Antero's language is extremely similar to that of Diamondback Energy. However, they talk more in terms of existing regulations than potential future regulations:

> "These laws and regulations may […] limit or prohibit activities in certain areas and on certain lands lying within **wilderness**, **wetlands**, frontier and other protected areas or areas with endangered or threatened species restrictions […].
>
> Existing environmental […] laws and regulations, as amended from time to time, to which our business operations are subject and for which compliance may have a material adverse impact on our financial position, results of operations or cash flows."

They do not single out biodiversity risk from other environmental regulation risks. Overall, the concern is that: operations may be limited or restricted, and/or compliance may negatively impact the company financially.

WETLANDS

Under Items 1 and 2. Business and Properties → Regulation of Environmental and Occupational Safety and Health Matters → Water Discharges, Antero Resources, like Diamondback Energy, dives into the recent back-and-forth around the scope of "regulated waters" (or "WOTUS", waters of the United States) covered by the Clean Water Act. Again, the challenge is determining whether the discharge of dredge and fill material in wetlands is prohibited without a permit. Antero offers a more in-depth explanation of the decisions and rulings from 2015-2023, and their sentiment is largely the same as Diamondback's:

[10] Which Antero uses (Antero Resources Corporation, 2024)

> "Some uncertainty remains as to how broadly the September 2023 rule and the Sackett decision will be interpreted by the agencies. To the extent the implementation of the final rule, results of the litigation, or any action further expands the scope of the CWA's jurisdiction in areas where we operate, we could face increased costs and delays with respect to obtaining permits for dredge and fill activities in **wetland** areas, which could delay the development of our natural gas and oil projects. Similarly, any increased costs or delays for such permits may impact the development of pipeline infrastructure, which may impact our ability to transport our products. Also, pursuant to these laws and regulations, we may be required to obtain and maintain approvals or permits for the discharge of wastewater or storm water and are required to develop and implement spill prevention, control and countermeasure plans, also referred to as "SPCC plans," in connection with on-site storage of significant quantities of oil. These laws and any implementing regulations provide for administrative, civil and criminal penalties for any unauthorized discharges of oil and other substances in reportable quantities and may impose substantial potential liability for the costs of removal, remediation and damages."

In addition to the risks mentioned by Diamondback, Antero also names increased costs or delays to building pipeline infrastructure as potential consequences of new permit requirements. Furthermore, they highlight possible requirements to develop spill prevention, control and countermeasure (SPCC) plans. Oil spills can be notoriously devastating for wildlife (Edmond, 2021). As such, regulation relating to them could be called a biodiversity transition risk.

It is pertinent to note that in 2023, Antero reported a spill intensity rate (Produced Liquid Spilled (Bbl)/Total Produced Liquids (MBbl)[11] of 0.0002. They had two agency reportable spills, totalling 5 Bbl (Antero Resources, 2024). This is significantly lower than Diamondback's spill rate of 0.015 and total spill volume of 1636 Bbl (Diamondback Energy, 2024). Yet it is Antero Resources who recognise the risk of spill-related regulations, which is notably absent from Diamondback's 10-K.

ENDANGERED SPECIES

Like Diamondback, Antero's 2023 10-K mentions the Endangered Species Act in two places: under Items 1 and 2. Business and Properties → Regulation of Environmental and Occupational Safety and Health Matters → Endangered Species Act; and under Item 1A. Risk Factors → "*Regulations related to the protection of wildlife could adversely affect our ability to conduct drilling activities in some of the areas where we operate*". Their description of these biodiversity transition risk in this context is similar to Diamondback's. However, Antero makes a clear distinction between the designation of a *species* as threatened or endangered, and the designation of a critical or suitable *habitat* where these species may live:

> "We conduct operations on natural gas and oil leases in areas where certain **species** that are listed as threatened or endangered are known to exist and where other **species** that potentially could be listed as threatened or endangered under the ESA may exist. The U.S. Fish and Wildlife Service ("USFWS"), may designate critical **habitat** and suitable **habitat** areas that it believes are necessary for survival of a threatened or endangered **species**. A critical habitat or suitable **habitat** designation could result in further material

[11] Bbl = barrels. 1 MBbl = 1000 Bbl.

> restrictions to federal land use and may materially delay or prohibit access to protected areas for natural gas and oil development."

They continue to separate out the consequences of these two risks:

> "The designation of previously unprotected **species** as threatened or endangered, or redesignation of a threatened **species** as endangered, in areas where underlying property operations are conducted could cause us to incur increased costs arising from **species** protection measures or could result in limitations on our exploration and production activities that could have an adverse impact on our ability to develop and produce reserves. If we were to have a portion of our leases designated as critical or suitable **habitat**, it could adversely impact the value of our leases."

I believe Antero presents a more holistic consideration of regulatory risks from species than Diamondback. They recognise that threatened or endangered *species* designations could result in increased mitigation costs, while critical or suitable *habitat* designations could result in decreased lease value. Both could impact the ability to develop and produce reserves.

Like Diamondback, Antero highlight that *seasonal* species protection restrictions could increase competition for components necessary to their operations:

> "Seasonal restrictions may limit our ability to operate in protected areas and intensify competition during those months for drilling rigs, oilfield equipment, services, supplies and qualified personnel, which may lead to periodic shortages. These constraints and the resulting shortages or high costs could delay our operations and materially increase our operating and capital costs."

Finally, Antero highlight the redesignation of the northern long-eared bat – which can be found in the areas where Antero operates – as endangered (from threatened) in November 2022. Yet:

> "We did not have any material capital or other non-recurring expenditures in connection with complying with environmental laws or environmental remediation matters in 2023, nor do we anticipate that such expenditures will be material in 2024."

Despite this redesignation of a species living in their area of operations as endangered, no material risk to Antero's operations was realised. This may be an encouraging precedent for Diamondback's current situation, following the designation of the dunes sagebrush lizard as endangered (Fish and Wildlife Service, 2024).

MITIGATION

According to their 2023 Environmental, Social and Governance Report, Antero "*work to integrate the management of biodiversity and resource protection throughout our project development and operational lifecycle*". They highlight that "*we are also evaluating the recommendations of the Taskforce on Nature-Related Financial Disclosures (TNFD) and will consider incorporating best practices where applicable*" (Antero Resources, 2024).

Antero's publicly available Biodiversity Policy details their process for identifying and minimising their impacts on biodiversity, reiterating their commitment to "*meet or exceed regulatory compliance*" (Antero Resources Corporation, 2023). According to this policy,

Antero implement the International Finance Corporation's hierarchy of avoidance, minimisation, restoration and mitigation (International Finance Corporation, 2012). Their mention of TNFD alludes to potential futher efforts to follow best practices. Overall, their efforts (or perceived efforts) to go above and beyond regulatory compliance could mitigate risks associated with non-compliance or the introduction of new regulations.

SUMMARY

These two high-market-value Oil & Gas firms focus on regulatory risks associated with the protection of wetlands, specific species, and their habitats. The regulations concern biodiversity protection at their hydrocarbon exploration sites, rather than the firms' more holistic impact on global biodiversity. These companies are concerned that these regulations could prohibit, restrict, delay, or require costly mitigation initiatives for, hydrocarbon exploration operations. They also discuss how seasonal species-protection restrictions could increase competition for equipment, labour and other elements necessary to their operations. They have both faced, or are currently facing, situations where a particular species living in their respective area of operations has been designated as endangered. However, Antero Resources claims that the redesignation of the long-eared bat as endangered has not resulted in any material capital or other non-recurring expenditures. It remains to be seen whether the same will be true for Diamondback Energy following the designation of the dunes sagebrush lizard as endangered. In terms of mitigation, both companies point to specific examples of how biodiversity considerations factor into their site development and operations, and Antero points to their consideration of the Taskforce on Nature-Related Financial Disclosures (TNFD) recommendations as a potential avenue for going beyond regulatory compliance.

A table summarising the biodiversity risks discussed in these two Oil & Gas firms' 2023 10-Ks can be found in Appendix 2.

METALS & MINING

Among the nine industries most likely exposed to biodiversity risk, the UN Environment Programme (2020) names Mining as a priority from an impacts (rather than dependencies) perspective. At the same time, Giglio, et al. (2024) rank the Materials sector, which includes the Metals & Mining industry as the fifth-most exposed industry to biodiversity risk. In 2023, 20% of sampled 10-Ks in the materials sector mentioned biodiversity. This is lower than Energy (40%) and Utilities (24%), but significantly higher than the fourth sector (Household and Personal Products), at only 8% (Industry Exposures, n.d.).

Mining and mineral processing use less than 0.02% of the Earth's surface (Maus, et al., 2020). However, evidence suggests that these activities have a disproportionate impact on biodiversity. For example, one study claims that mining induced 9% of deforestation in the Amazon between 2005 and 2015 (Sonter, et al., 2017). The Amazon is one of the most biodiverse areas on Earth (World Bank Group, 2019). Mining activities affect biodiversity at site, regional and indeed global levels (Sonter, Ali, & Watson, 2018). As with Oil and Gas, it follows that Metal and Mining's high impact on biodiversity would expose it to regulatory, legal and reputation risks – transition risks.

At the same time, mining has multiple material dependencies on nature (Natural Capital Finance Alliance and UN Environment World Conservation Monitoring Centre, 2018). For example, biodiversity loss can increase water scarcity because biodiverse ecosystems regulate water cycles (Elanco, 2024). Water is critical to mining operations (Concha Larrauri, Lall, Siegel, & Arbarzua, 2019). Therefore, the industry could be exposed to physical as well as transition biodiversity risks.

Before examining how two Metals & Mining firms consider biodiversity risk, a note on their annual filings: alongside a 10-K, mining companies must submit an S-K 1300. This requires firms to provide technical report summaries on all properties that are material to their business (Mining Plus, 2020). The following analyses consider Alcoa and Warrior Met Coal's respective 2023 S-K 1300s only insofar as they pertain to biodiversity risk.

ALCOA

Founded in 1888 as the The Pittsburgh Reduction Company, Alcoa (Aluminum Company of America) was one of the first mass producers of aluminum (Alcoa, n.d.). Today, they are active in all aspects of the upstream aluminum industry: bauxite mining, alumina refining, and aluminum smelting and casting (Alcoa, 2023). Alcoa is Headquartered in Pittsburgh, Pennsylvania. As of January 31, 2025, it has a market capitalisation of $9.33 billion (Yahoo Finance, 2025) and is ranked 380th in the Fortune 500 (Fortune, 2024).

Alcoa operates in seven countries: Australia, Brazil, Canada, Iceland, Norway, Spain and the US (plus Guinea and Saudi Arabia via joint ventures). For a full breakdown of Alcoa's operations by site and country, see Appendix 7. Conducting mining and related operations in seven countries, some also members of political and economic unions,[12] could expose Alcoa to biodiversity transition risks from multiple sources.

PERMITS

The first mention of biodiversity-related risk in Alcoa's 2023 10-K (Alcoa Corporation, 2024) comes under Item 1A. Risk Factors → Industry & Global Market Risks → *"We have in the past been and may in the future be unable to obtain, maintain, or renew permits or approvals necessary for our mining operations, which could materially adversely affect our operations and profitability."* Following a general discussion of permit-related risks, the report continues:

> "In addition, these processes, restrictions, and requirements have in the past resulted and could in the future result in the Company's mining permits being rescinded or modified, or adjustment to our mining plans, to mitigate against adverse impacts to sites within or near our mining areas that have environmental, **biodiversity**, or cultural significance. Such actions have in the past had and could in the future have a material adverse impact on our results of operations and profitability. For example, the Company seeks annual approvals from the Western Australia government for rolling five-year mine plans to maintain operations at the Huntly and Willowdale bauxite mines. This statutory annual mine approvals process for the Company's 2023-2027 Mining and Management Program (MMP) took longer than it had taken historically due to increased requirements and expectations from stakeholders with respect to certain environmental matters. As a result of the prolonged approval process, the Company

[12] Spain is a member of the EU. Brazil is a member of Mercosur.

> began mining lower grade bauxite in April 2023, which impacted the Company's refineries by increasing the use of caustic, energy, and bauxite and decreasing alumina output. The Company's 2023-2027 MMP was approved in December 2023, and in connection with such approval, the Company is subject to certain new requirements to address key environmental factors, such as enhanced protections for drinking water, increased distances from reservoirs, **biodiversity**, and accelerated **forest** rehabilitation. The new requirements will require an acceleration of cash spend of approximately $40 [$ amounts in millions] over the next three and half years from asset retirement obligations already recorded."

This update on the Huntly and Willowdale bauxite mines is repeated in a later section, under Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations → Business Update → Australia Mine Plan Approvals.

Like other firms across industries in this study, Alcoa mentions potential adjustments to operations because of compliance with biodiversity-related regulation. However, Alcoa is the only firm to explicitly recognise the risks that have *already* been realised. Firstly, delays in obtaining permits for the continued operation of the Huntly and Willowdale mines lead Alcoa to mine lower-grade bauxite for eight months. This resulted in increased resource use, and decreased alumina output. Secondly, the eventually obtained permits carried conditions relating to biodiversity and forest rehabilitation. Alcoa quantifies the cost of compliance with these regulations: $40 million over the next three and a half years. Again, they are the only firm in the present paper that explicitly quantifies the operational and financial impact of compliance with biodiversity regulations. Not all of these permit delays and additional costs necessarily result directly from biodiversity-related regulation, since biodiversity and forest rehabilitation are mentioned alongside other environmental matters.

DEFORESTATION

Alcoa's other mention of biodiversity risk also comes under Item 1A. Risk Factors. It is within Legal and Regulatory Risks → "*Climate change, climate change legislation or regulations, and efforts to reduce greenhouse gases (GHG) and build operational resilience to extreme weather conditions may adversely impact our operations and markets*":

> "In addition, regulations to combat climate change could impact the competitiveness of the Company, including the attractiveness of the locations of some of the Company's assets. The global focus on climate is raising awareness in all countries, such as the agreement at the 26th United Nations Climate Change Conference of the Parties (COP26) by many governments of countries where the Company operates to combat **deforestation**, which could adversely affect our ability to mine and operate in sensitive areas like the Jarrah **Forest** [in Western Australia] and the Amazon."

While this section concerns regulations around climate change rather than biodiversity specifically, deforestation is a matter of biodiversity loss *as well as* climate change. As explored in the introduction to Metals & Mining in the present work, it is no secret that mining is a significant driver of deforestation – including in the Amazon. As part of COP26, 145 countries signed the Glasgow Leaders' Declaration on Forest and Land Use. This includes all seven countries where Alcoa operates (UN Climate Change Conference UK 2021, 2021). However, the declaration on deforestation that these countries' governments signed only expresses their commitment to working together to combat deforestation. It does not commit the signatories

to specific actions or goals. So, it is unsurprising that Alcoa expresses only speculative concerns around resulting risk.

ALCOA SK 1300

Alcoa's 2023 S-K 1300 Report (included alongside its 10-K) contains numerous mentions of terms in the biodiversity dictionary, including *biodiversity*, *habitat*, *species* and *fauna*. However, as expected from a technical report, these mentions describe the company's actions to comply with mining operation regulations. They do not relate to physical or transition *risks* to Alcoa's business. Therefore, examining these mentions is outside the scope of this paper.

MITIGATION

Alcoa's 2023 Sustainability Report (Alcoa, 2023) points to some examples of mitigation strategies. For example, in 2023 the company created a new Center of Excellence (CoE) for Biodiversity. Plus:

> "We also undertook a portfolio-level review of our **biodiversity** assets and their ecosystem value, with the objective of updating and standardizing **biodiversity** and ecosystem services risks and dependencies across our operations. We expect to complete these risk assessments by the end of 2025, which will allow us to report in line with internationally recognized frameworks, such as the Taskforce on Nature-related Financial Disclosures (TFND)."

With this in mind, we may expect to see Alcoa expanding its considerations of biodiversity-related risk in coming years. Establishing this CoE and undertaking this review to align with TFND best practices, may be proactive biodiversity risk mitigation strategies. However, these actions may have been motivated by necessity. Alcoa's membership of the International Council on Mining and Metals (ICMM) requires them to meet sustainability performance requirements. In its 2022 self-assessment, Alcoa found that all of its sites met 93% of applicable ICMM Performance Expectations. The other 7%, which were only partially met, included the expectations associated with Biodiversity and Water Management.

In this report, Alcoa also share that they are working towards achieving no net loss (NNL) of biodiversity and priority ecosystem services across all sites relative to a designated baseline condition. They detail some ways that they manage their impacts and dependencies on biodiversity, a process which "*has been guided for many years by Alcoa's Biodiversity Standard and Biodiversity Policy*". This includes implementing Biodiversity Action Plans for every site, which address impact pathways on flora and fauna and outline actions and targets to minimise negative impacts.

WARRIOR MET COAL

Formed in 2015, Warrior Met Coal mines non-thermal metallurgical coal (met coal). Met coal is a critical component of steel production (Warrior, 2023). It is headquartered in Brookwood, Alabama. As of January 31, 2025, its market capitalisation is $2.79 billion (Yahoo Finance, 2025). Warrior operates two mines, both in West Alabama (Warrior Met Coal, n.d.). A 2020 interactive map shows relative richness of imperilled species in West Alabama (see Appendix 8).

GENERAL ENVIRONMENTAL REGULATION

The first time that biodiversity risk is mentioned in Warrior Met Coal's 2023 10-K (Warrior Met Coal, Inc., 2024) is under Item 1A. Risk Factors → Risks Related to Regulatory Compliance:

> "**Extensive environmental, health and safety laws and regulations impose significant costs on our operations and future regulations could increase those costs, limit our ability to produce or adversely affect the demand for our products**.
>
> Our businesses are subject to numerous federal, state and local laws and regulations with respect to matters such as: […] environmental laws and regulations, including those related to […] protection of plant and **wildlife** such as endangered **species**, protection of **wetlands** and remediation of contaminated soil and groundwater.
> Compliance with applicable federal, state and local laws and regulations may be costly and time-consuming and may delay commencement or interrupt continuation of exploration or production at one or more of our operations. These laws are constantly evolving and may become increasingly stringent. The ultimate impact of complying with existing laws and regulations is not always clearly known or determinable due in part to the fact that certain implementing regulations for these laws have not yet been promulgated and in certain instances are undergoing revision. These laws and regulations, particularly new legislative or administrative proposals (or judicial interpretations of existing laws and regulations), along with analogous foreign laws and regulations, could result in substantially increased capital, operating and compliance costs and could have a material adverse effect on our operations and/or our customers' ability to use our products."

As is common among the 10-Ks examined in this paper, this passage expresses potential risks of monetary or time costs, delays, or interruptions to operations associated with compliance with biodiversity-related regulations. The risk of regulations changing – be it new regulations, or new interpretations of existing regulations – is also highlighted. But as Warrior Met Coal explicitly point out, it is challenging to know the ultimate operational or financial impact of compliance. Many existing laws haven't actually come into effect yet.

That said, under Part I, Item 1. Business → Description of Our Business → Environmental and Regulatory Matters:

> "In the U.S., environmental laws and regulations include, but are not limited to […] the Endangered **Species** Act with respect to protection of threatened and endangered **species** […].
>
> Due in part to the extensive and comprehensive regulatory requirements, along with changing interpretations of these requirements, violations occur from time to time in our industry and at our operations. Expenditures relating to environmental compliance are a major cost consideration for our operations and environmental compliance is a significant factor in mine design, both to meet regulatory requirements and to minimize long-term environmental liabilities. To the extent that these expenditures, as with all costs, are not ultimately reflected in the prices of our products and services, operating results will be reduced. We believe that our major North American competitors are confronted by substantially similar conditions and thus do not believe that our relative position with regard to such competitors is materially affected by the impact of

> environmental laws and regulations. However, the costs and operating restrictions necessary for compliance with environmental laws and regulations may have an adverse effect on our competitive position with regard to foreign producers and operators who may not be required to undertake equivalent costs in their operations."

There are two notable aspects to this passage. Firstly, Warrior alludes to already-realised risks from biodiversity-related regulation: "expenditures relating to environmental compliance are a major cost consideration for our operations". Secondly, they highlight the geopolitical specificity of regulations and how these can impact international competition. Warrior believe that operating in North America could put them at a disadvantage compared to firms operating in countries with less strict environmental (including biodiversity-related) regulation.

ENDANGERED SPECIES

Finally, Warrior Met Coal's 2023 10-K includes a section on transition risks associated with species protection. Under Part I, Item 1. Business → Description of Our Business → Environmental and Regulatory Matters:

> ***"Endangered Species Act and Similar Laws***
> […] Protection of threatened, endangered and other special status **species** may have the effect of prohibiting or delaying us from obtaining mining permits and may include restrictions on our activities in areas containing the affected species. Also, the designation of previously unidentified threatened, endangered or special status **species** in areas where we operate could cause us to incur additional costs or become subject to operating delays, restrictions or bans."

This passage is similar to passages in the 2023 10-Ks of Diamondback Energy and Antero Resources in the Oil & Gas industry. Warrior expresses that protection of threatened or endangered species – including previously-unprotected species – may prohibit or delay their ability to obtain mining permits; restrict their activities; or incur additional costs. They do not quantify probability or ultimate consequences of such risks, nor share specific examples of this having occurred.

WARRIOR MET COAL SK 1300

Of all the firms and documents in this study, we find the most in-depth, quantified analysis of biodiversity-related business risk in Warrior's 2023 SK 1300 filing (Warrior Met Coal, Inc., 2024). Although not strictly part of their 10-K statement, mining firms are required to include the SK 1300 with the 10-K.[13] This Technical Report Summary pertains to the Blue Creek Mine Property, a proposed Warrior Met Coal mine in Tuscaloosa County, Alabama.

Under section 22.2. Project Risk Assessment is a consequence level table (Figure 1). The column *Events Impacting on the Environment* proposes scenarios in which the mine's development impacts local habitats, species populations and ecosystem functions. Each event is assigned a severity level and the expected financial and operational impacts are quantified.

An *Insignificant* event would include "insignificant loss of habitat", cost <$1 million, and have ≤ 12 hours impact on commercial operations. At the other extreme, a Category 5 Critical event

[13] See introduction to Metals & Mining.

could include species extinction or irreversible damage to ecosystem function. This would cost ≥ $20 million and lead to a > 1 month impact on commercial operations. This thorough consideration of business risks associated with biodiversity loss could serve as a blueprint for other Metals & Mining firms' SK 1300s. It could also be adapted for 10-K statements across several industries.

Table 22-2: Consequence Level Table

Correlation of Events in Key Elements of the Project Program to Event Severity Category							
Category	Severity of the Event	Financial Impact of the Event	Unplanned Loss of Production (Impact on Commercial Operations)	Events Impacting on the Environment	Events Affecting the Program's Social and Community Relations	Resultant Regulatory / Sovereign Risk	Events Affecting Occupational Health & Safety
1	**Insignificant**	< $1MM	≤ 12 hours	Insignificant loss of habitat; no irreversible effects on water, soil and the environment.	Occasional nuisance impact on travel.		Event recurrence avoided by corrective action through established procedures (Engineering, guarding, training).
2	**Minor**	$1MM to $4MM	≤ 1 day	No significant change to species populations; short-term reversible perturbation to ecosystem function.	Persistent nuisance impact on travel. Transient adverse media coverage.		**First aid – lost time.** Event recurrence avoided by corrective action thought established procedures.
3	**Moderate**	$4MM to $10MM	≤ 1 week	Appreciable change to species population; medium-term (≤10 years) detriment to ecosystem function.	Measurable impact on travel and water/air quality. Significant adverse media coverage / transient public outrage.	Uncertainty securing or retaining essential approval / license. Change to regulations (tax; bonds; standards).	**Medical Treatment –** permanent incapacitation Avoiding event recurrence requires modification to established corrective action procedures.
4	**Major**	$10MM to $20MM	1 to 2 weeks	Change to species population threatening viability; long-term (>10 years) detriment to ecosystem function.	Long-term, serious impact on travel and use of water resources; degradation of air quality; sustained and effective public opposition.	Suspension / long-delay in securing essential approval / license. Change to laws (tax; bonds; standards).	**Fatality.** Avoiding event recurrence requires modification to established corrective action procedures and staff retraining.
5	**Critical**	> $20MM	>1 month	Species extinction; irreversible damage to ecosystem function.	Loss of permits.	Withdraw / failure to secure essential approval / license.	**Multiple fatalities.** Avoiding event recurrence requires major overhaul of policies and procedures.

Figure 1

MITIGATION

Warrior Met Coal's 2023 Corporate Responsibility Report (Warrior, 2023) states that:

> "We are deeply committed to understanding and mitigating our environmental impact, particularly concerning the rich **biodiversity** surrounding our operations in Alabama.[…] Our efforts have been acknowledged through industry accolades, including the 2021 and 2022 Land Stewardship Awards and the 2023 Water Quality Stewardship Award [from the Alabama Mining Association, most recently for a **wetland** development project], reflecting our ongoing dedication to environmental excellence."

Like other companies in this study, they highlight their efforts to go above and beyond regulatory compliance. Given the specific risks associated with their dredge and fill activities in wetlands, it is particularly notable that Warrior won an award for a wetland development project. In their business-as-usual operations, actions to account for biodiversity impact include working with regulatory bodies including the Alabama Department of Environmental Management and US Fish and Wildlife Service and conducting environmental studies.

SUMMARY

In Metals & Mining, no discussed risks are common to the two firms. Alcoa recognises that deforestation regulations resulting from COP26 could impact their competitiveness and the attractiveness of their site locations. They also share how complying with biodiversity protection and forest rehabilitation requirements in Western Australia is expected to cost the firm $40 million over the next three and a half years. Meanwhile, Warrior Met Coal acknowledges how species protection regulation could prohibit or delay operations, increase costs, and ultimately impact their competitiveness with non-US operators. A Technical Summary Report in Warrior Met Coal's 2023 SK 1300 contains the most thorough exploration of biodiversity-related transition risk of any document in this study. Both firms give examples of their efforts to minimise impacts on biodiversity, and hence mitigate risks from biodiversity loss, in their respective Sustainability and Corporate Responsibility reports. Alcoa focuses more on reviewing and enhancing their biodiversity standards, and Warrior more on specific impact mitigation projects for which they have been recognised by the Alabama Mining Association.

A table summarising the biodiversity risks discussed in these two Metals & Mining firms' 2023 10-Ks can be found in Appendix 3.

AGRICULTURAL PRODUCTS

The UN Environment Programme (2020) names Agricultural Products in its nine top industries most likely exposed to biodiversity risk. It deems it a priority from *both* a dependencies (on biodiversity) and impacts (on biodiversity) perspective. Giglio, et al. (2024) also place Food, Beverage and Tobacco[14] in the top five most exposed sectors to biodiversity risk.

Agriculture is highly dependent on nature. Indeed, the World Economic Forum (2022) names it in the three largest sectors highly dependent on nature. Agriculture relies on ecosystem services like maintenance of soil fertility, resistance to pests and diseases, and pollination of crops (European Commission, 2024). This means it is exposed to physical risks from biodiversity loss.

At the same time, the global food system may be the primary driver of worldwide biodiversity loss (Benton, Bieg, Harwatt, Pudasaini, & Wellesley, 2021). At the time of writing, agriculture and aquaculture is an identified threat to 60%[15] of the critically endangered and endangered species on the IUCN's red list (IUCN Red list, n.d.). Efforts are underway to explore farming practices that enhance biodiversity (Cozim-Melges, et al., 2024). Until these practices become widespread, agriculture's impact on biodiversity exposes it to transition risks.

As elaborated in the present paper's Methodology, the following two companies were chosen from a larger dataset than Giglio, et al.'s publicly available biodiversity metric data.

[14] Under which Agricultural Products falls in GICS classifications.

[15] Critically endangered and endangered species, threatened by agriculture and agriculture: 17,185. Critically endangered and endangered species, total: 28,923.

ARCHER-DANIELS-MIDLAND

The Archer-Daniels-Midland Company (otherwise known as ADM) is a multinational food processing and commodities trading corporation founded in 1902. It is headquartered in Chicago, Illinois. As of January 31, 2025, ADM has a market capitalisation of $24.66 billion (Yahoo Finance, 2025). In 2024, it was 43rd in the Fortune 500 and 117th in the Fortune Global 500 (Fortune, 2024).

In over 120 years of business, ADM has grown organically and via acquisitions to encompass a vast array of products and brands (Archer-Daniels-Midland, n.d.). Their activities encompass the entire supply chain from the origination and transportation of agricultural raw materials; to the processing of oilseeds and grains into oils, starches, and syrups; to the manufacturing of plant-based proteins, flavourings, and animal feed (Archer-Daniels-Midland, 2024). Their primary raw materials are oilseeds,[16] particularly soy, and grains.[17] ADM's operational footprint spans over 150 countries, on six continents (Archer-Daniels-Midland, 2024). The material dependencies of ADM's business, plus their international operations, could expose them to physical and transition risks related to biodiversity.

PHYSICAL RISK

ADM's 2023 10-K (Archer-Daniels-Midland, 2024) may make subtle allusions to physical biodiversity risk. Under Item 1. Business → Environmental, Social, and Governance (ESG):

> "The Company knows that the health of our natural resources is critical to our future"

And:

> "The Company believes that protection of natural resources, **habitats**, and **biodiversity** are important to life and to the Company's business."

These mentions are not explicit, but they do acknowledge the business' dependence on biodiversity. As such, they may be interpreted as alluding to physical risks associated with biodiversity loss.

DEFORESTATION

ADM's recognition of transition risks is more concrete. Under Item 1A. Risk Factors:

> ***"Operations could be impacted by the European Union (EU) deforestation-free regulation as part of the EU Green Deal.***
>
> The EU **deforestation**-free regulation was approved late 2022 and is effective December 2024. The regulation affects seven specific commodities (i.e. cocoa, coffee, soy, palm oil, wood, rubber, and cattle) and their derivatives, as well as products made using these commodities (e.g. leather, cosmetics, chocolate, etc.). Soybean is the primary commodity that could be impacted due to the volume of export into and used in production in the EU. Failure to comply with the regulation could have serious

[16] Such as soybean, rapeseed, cottonseed, sunflower and peanut.
[17] Such as wheat and corn.

consequences including civil, administrative, and criminal penalties, as well as negative impact on the Company's reputation, business, cash flows, and results of operations."

Here we see how the deforestation impact of soy and palm crops translates into regulatory risk. Many potential impacts of regulatory compliance are similar to those seen in 10-Ks across all industries in this study. However, a key difference is ADM's mention of potential negative impact on the company's *reputation*. Reputational risk is more ephemeral than regulatory risk, but both are types of transition risk. Notably, among the firms studied in the present work, those in the Agricultural Products industry mention reputational risks associated with biodiversity, whereas those in the Oil & Gas and Metals & Mining industries do not.

Readers should also note that the EU deforestation-free regulations mentioned in this passage will ban the sale in the EU of products sourced from deforested land. These regulations have been updated since the publication of ADM's 2023 10-K. Originally, firms were expected to comply by the end of 2024. However, in December 2024 it was announced that effective date would be moved to December 30, 2025 (European Parliament, 2024). This additional year to prepare for the EUDR may have mitigated some risks discussed by ADM.

MONITORING AND REPORTING

ADM's final mention of transition risk is also specific to the EU. It includes biodiversity, although under the umbrella of general sustainability. Under Item 1A. Risk Factors:

> ***"The Company's sustainable practices require oversight and robust monitoring requirements. The lack of unified reporting standards increases sustainability regulatory compliance and reporting requirements.***
>
> The Company has programs and policies in place (e.g., Corporate Sustainability Program; Commitment to Protecting **Forests**, **Biodiversity** and Communities; Environmental Policy; Strive 35 environmental goals; etc.) to expand responsible practices while reducing its environmental footprint and to help ensure compliance with laws and regulations. […] Starting in 2026, the Corporate Sustainability Reporting Directive (CSRD) will require companies within the European Union to report extensive climate-related information for the 2025 financial year. The reporting requirements of CSRD, along with the growing multitude of corporate sustainability reporting standards, will result in increased compliance costs and could result in regulatory reporting risks as each standard will have its own required disclosures. Failure to comply with laws and regulations can have serious consequences, including civil, administrative, and criminal penalties as well as a negative impact on the Company's reputation, business, cash flows, and results of operations."

The CSRD mentioned includes a standard on Biodiversity and Ecosystems (Tortora, 2024). The risk discussed here does not pertain to operational compliance with regulation, but to *reporting* on this compliance. ADM is concerned that compliance costs and the liabilities associated with infringement of the reporting standards could negatively impact their business operationally, financially, and reputationally.

MITIGATION

ADM's most recent Sustainability Report elaborates on its actions and initiatives to comply with and exceed biodiversity regulations (Archer-Daniels-Midland, 2023). It includes 16 biodiversity-related goals. Most notably given the specific risks discussed in their 2023 10-K, these include 100% deforestation-free across all supply chains by the end of 2025 (progress not reported) and 100% deforestation-free soy by the end of 2025 (86% in progress). These goals align with the EU Deforestation Regulation which will prevent the sale in the EU of soy from deforested land from December 30, 2025, mitigating risks associated with non-compliance.

BUNGE GLOBAL SA

Bunge is the oldest company studied in this paper, founded as an import-export business in Amsterdam in 1818 (Bunge, n.d.). Now, Bunge's registered office is in Geneva, Switzerland and its corporate headquarters in St. Louis, Missouri (Bunge, 2023). Like Archer-Daniels-Midland, Bunge has grown in size and complexity. As of January 31, 2025, it has a market capitalisation of $10.77 billion (Yahoo Finance, 2025). Operating as a holding company, Bunge organises its business into four reportable segments: Agribusiness, Refined and Specialty Oils, Milling, and Sugar and Bioenergy (Bunge Global SA, 2024). Their core segments encompass the trade, export, and processing of oilseeds (such as soybeans) and grains. They describe themselves as "the world's leader in oilseed processing and a leading producer and supplier of specialty plant-based oils, fats and protein". Their products are ingredients for animal feed, biofuels, plant-based meat and more. They also produce end products such as cooking oil (Bunge, n.d.). Bunge operates in 40 countries on six continents (Bunge Global SA, 2024). Like ADM, Bunge's primary inputs are oilseed and grains. This coupled with their international operations could expose them to both physical and transition risk from biodiversity loss.

DEFORESTATION

The first mention of biodiversity risk in Bunge's 2023 10-K (Bunge Global SA, 2024) concerns regulatory risk associated with deforestation. Under Item 1. Business → Government regulation:

> **"**Our business could also be affected by […] regulations related to conservation and eliminating **deforestation**. A number of jurisdictions in which we operate have implemented or are in the process of implementing […] regulations to reduce GHG emissions or deforestation, including, but not limited to, the United States, Canada, Mexico, the European Union and its member states, and China […] The European Union **Deforestation** Regulation ("EUDR"), which is scheduled to become effective in December 2024, will require companies trading in certain commodities, including oil palm and soy, as well as products derived from these commodities, to ensure these commodities and related products do not result from **deforestation, forest** degradation, or breaches of local laws after December 31, 2020 in order to sell such products in the European Union. We are in the process of assessing the impact of the EUDR on Bunge. Our operations […] currently meet related existing obligations with, at this time, no significant impact on our results of operations and competitive position. We regularly assess the potential impacts to our business resulting from regulation or policies aimed at reducing GHG emissions and **deforestation**. Potential consequences could include

> increased energy, transportation and raw material costs, and additional investments to modify our facilities, equipment and processes."

This section discusses deforestation and forest degradation regulation alongside greenhouse gas emission regulation. However, it clearly singles out the EUDR. As mentioned in the Deforestation section of the examination of Archer-Daniels-Midland, the implementation of this EU regulation has been pushed back to December 30, 2025. Bunge do not share any expected impacts of the EUDR at this stage. However, they speculate that adhering to deforestation regulation could lead to increased costs. This far, it has thus far had no "significant" impact on the results of their operations or competitive position. They revisit the EUDR Under Item 1A. Risk Factors, adding:

> "The EUDR, which is scheduled to become effective in December 2024, will require companies trading in certain commodities, including oil palm and soy, as well as products derived from these commodities, to ensure these commodities and related products do not result from **deforestation**, **forest** degradation, or breaches of local laws after December 31, 2020 in order to sell such products in the European Union. The imposition of regulatory restrictions related to GHG emissions and conservation in many markets in which we operate […] could affect land-use decisions, the cost of agricultural production and the cost and means of processing and transporting our products, which could adversely affect our business, cash flows, and results of operations."

The ultimate impacts described here – adverse effects on cash flows and results of operations – relate to the possibility of regulatory restrictions being imposed in *multiple* markets where they operate. This highlights how multinational operations may disperse regulatory risk. That is, the EU regulation alone may not present a significant risk to the holding company's operations or finances. In contrast, firms relying on one country for a significant portion of their operations – such as Warrior Met Coal, with mining sites only in Alabama, USA – could suffer greater losses if restrictions were imposed in that country.

REPUTATION

The final way in which Bunge discuss biodiversity risk is under Item 1A. Risk factors:

> ***"We are subject to industry and other risks that could adversely affect our reputation and financial results.***
> […] Increasing focus on climate change, **deforestation**, water, animal welfare and human rights concerns, and other risks associated with the global food system may lead to increased activism focusing on food companies and their suppliers, governmental intervention and consumer responses. These risks could adversely affect our, or our suppliers', reputations and businesses and our ability to procure the materials we need to operate our business.
>
> As a company whose products comprise staple food and feed products sold globally, as well as ingredients included in trusted food brands of our customers, maintaining a good corporate reputation is critical to our continued success. Reputational value is based in large part on perceptions, which can shift rapidly in response to negative incidents. The failure or alleged failure to maintain high standards for quality, safety, integrity, environmental sustainability and social responsibility, including with respect to raw

> materials and services obtained from suppliers, even if untrue, may result in tangible effects, such as reduced demand for our products, disruptions to our operations, increased costs and a loss of market share to competitors."

Again, this passage includes deforestation alongside other environmental and social responsibility concerns, so does not pertain wholly to *biodiversity* risk. But what is notable here is Bunge's acknowledgement of risks from *reputational* damage. As Bunge point out, failure to meet customer or public expectations of environmental responsibility need not be *true* for it to damage the company's business. A perceived failure is enough to reduce demand for its products, disrupt operations, increase costs and lead to loss of market share.

MITIGATION

Like ADM, Bunge have also implemented a 2025 non-deforestation commitment. A report on their progress toward this goal, focusing on soy from South America and palm from Asia, is enclosed within their 2024 Sustainability Report (Bunge, 2024). Bunge report that they are on track to achieve their non-deforestation goal in 2025. Like for ADM, this will ensure Bunge's adherence to the EU Deforestation Regulations and mitigate risks associated with non-compliance.

Bunge's Sustainability Report also points out their participation in the Taskforce on Nature-related Financial Disclosures (TNFD). They say:

> "Since 2021, Bunge has been an active participant in the Taskforce on Nature-related Financial Disclosures (TNFD), an initiative to improve governance and transparency on nature-related issues. Bunge has established itself as an early adopter and has supported the development of new indicators and reporting guidelines for companies to disclose their **biodiversity** and nature impacts, and their dependencies."

They then detail their implementation of the TNFD's LEAP framework: *Locate* the company's interface with nature across geographies and value chain; *Evaluate* the dependencies and impacts on the nature; *Assess* the nature-related risks and opportunities; and *Prepare* the response to nature-related risks and opportunities. This enhanced level of disclosure could mitigate the biodiversity-related reputation risks discussed in Bunge's 2023 10-K.

SUMMARY

The Agricultural Products industry is highly dependent on biodiversity. However, neither Archer-Daniels-Midland nor Bunge Global SA explicitly discusses physical risk from biodiversity loss in their 2023 10-K, beyond a potential allusion by ADM. Both firms discuss transition risks associated with incoming EU deforestation regulations (EUDR), which will impact the sale of soy that is central to both businesses. Risks include increased costs associated with compliance, and an ultimate negative impact on cash flows and the results of operations. Both firms also recognise the importance of reputation to their businesses. As such, they see that perceived failure to adequately protect biodiversity could reduce demand for their products, disrupt operations and ultimately lead to a loss in market share. No other companies studied in this paper, in Oil & Gas or Metals & Mining, express such concerns in their 2023 10-Ks. Both Agricultural Products companies highlight risk mitigation strategies in their most recent Sustainability Reports. Notably, both have committed to 100% deforestation-free products by the end of 2025, ensuring compliance with the EU Deforestation Regulation.

Bunge has also adopted the TNFD's LEAP framework for biodiversity data collection, which may mitigate reputation risk by going beyond regulatory compliance.

A table summarising the biodiversity risks discussed in these two Agricultural Products firms' 2023 10-Ks can be found in Appendix 4.

CONCLUSION

This paper has built on Giglio, et al.'s findings on industry and firm-level exposures to biodiversity risk (Biodiversity Risk, 2024). These authors found evidence that some firms in highly exposed industries discuss biodiversity risk in their 2023 10-K statements. This paper has illustrated *how* these firms discuss biodiversity risks.

It has provided case studies of how six high-market-value firms in three highly exposed industries discuss biodiversity risk. It has done so through analysis of their 2023 10-K statements, based on simple text searches for terms in Giglio, et al.'s 2023 biodiversity dictionary (Giglio, Kuchler, Stroebel, & Zeng, Biodiversity Risk, 2023) combined with human comprehension.

It has found that in their 2023 10-Ks, all six companies recognise transition risks associated with biodiversity loss. However, they do not overtly discuss physical risk. Firms in the same industry sometimes recognise common risks. For example, both Oil & Gas firms discuss risks from seasonal operating restrictions associated with species protection, which could lead to increased competition for labour and equipment. And both firms in the Agricultural Products industry discuss how a perceived failure to adequately protect biodiversity could damage their reputations, reducing demand for their products. Full summaries of the risks, impacts, and mitigation strategies discussed, by firm and by industry, are available in Appendix 1 - Appendix 4.

While this work has generated insight into firm-level discussion of biodiversity risk, it has limitations. Firstly, the search for discussion of biodiversity risk in each respective 10-K was limited to 20 terms in Giglio, et al.'s (2023) biodiversity dictionary. Expansion of the search terms, for example using the same authors' updated (2024) 100-term dictionary, may uncover more evidence. In addition, natural language processing methods like entity recognition may allow for more holistic identification of biodiversity-related risk. For example, a firm may mention risks from the endangerment of specific species without using the term species. Entity recognition may be able to identify these cases. Secondly, a more comprehensive exploration of firm-level biodiversity risk discussions may include more sources than the respective firms' 10-Ks.

Thirdly, firms were chosen based on the size of their market capitalisations at a particular point in time. There may be value in selecting a "typical" firm in an industry – although the methodology for determining "typicality" would need careful consideration. Alternatively, one could select firms that discuss biodiversity risk most substantively. For example, the textual analysis models employed by Giglio, et al. (2024) may be adapted to identify not only that a firm mentions biodiversity in two or more sentences; but in *how many* sentences.

Finally, human comprehension is neither robust nor infallible. As such, this paper's insights may be limited by my own comprehension. I see great potential value in a dual approach to textual analysis: employing both human understanding and computational methods. For example, Giglio, et al. (2024) attempt to use a Large Language Model[18] to categorize biodiversity risks across firms and industries as physical or transition risks. I have attempted to do the same for the six firms in this study, using my own comprehension (see Appendix 1). Further refinement of this Large Language Model methodology would be a welcome next step toward scaling this work and expanding our understanding of how firms are considering biodiversity risk.

[18] ChatGPT.

WORKS CITED

Alcoa. (2023). *2023 Annual Report.* Retrieved January 2025, from Alcoa: https://s29.q4cdn.com/945634774/files/doc_financials/2023/ar/alcoa-corp-2023-annual-report-final-bookmarked.pdf

Alcoa. (2023). *2023 Sustainability Report.* Retrieved January 2025, from https://www.alcoa.com/sustainability/pdf/2023-Sustainability-Report.pdf

Alcoa Corporation. (2024, February 21). *Form 10-k for the fiscal year ended December 31, 2023.* Retrieved January 2025, from Securities and Exchange Commission: https://www.sec.gov/ix?doc=/Archives/edgar/data/1675149/000095017024018069/aa-20231231.htm

Alcoa. (n.d.). *Our History: A Legacy of Innovation*. Retrieved January 2025, from Alcoa: https://www.alcoa.com/global/en/who-we-are/history

Antero Resources. (2024, July 31). *ESG Report.* Retrieved January 2025, from Antero Resources: https://d1io3yog0oux5.cloudfront.net/_f8b20d715bb7cf4584a00c8e02801fca/anteroresources/db/847/7560/esg_report/Antero-Resources-ESG-2024-07-31-v3.pdf

Antero Resources. (2025). *About Us*. Retrieved January 2025, from Antero Resources: https://www.anteroresources.com/about-us

Antero Resources Corporation. (2023, April 11). *Biodiversity Policy.* Retrieved January 2025, from https://d1io3yog0oux5.cloudfront.net/_2163fd53228150102affc97d8847e7fb/anteroresources/db/742/7280/file/AR+-+Biodiversity+Policy+%28Final+as+of+4-11-23%29.pdf

Antero Resources Corporation. (2024, February 14). *Form 10-k For the fiscal year ended December 31, 2023.* Retrieved January 2025, from Securities and Exchange Commission: https://www.sec.gov/ix?doc=/Archives/edgar/data/1433270/000155837024001162/ar-20231231x10k.htm

Archer-Daniels-Midland. (2023). *Scaling Impact: 2023 Corporate Sustainability Report.* Retrieved January 2025, from Archer-Daniels-Midland: https://www.adm.com/globalassets/sustainability/sustainability-reports/final_archer-daniels-midland-adm_2023-corporate-sustainability-report_51424.pdf

Archer-Daniels-Midland. (2024). *Form 10-K for Fiscal Year Ended December 31, 2023.* Chicago, IL: Archer-Daniels-Midland.

Archer-Daniels-Midland. (n.d.). *The History of ADM*. Retrieved January 2025, from ADM: https://www.adm.com/en-us/about-adm/our-company/history/

Beckmann, J., Murray, K., Seidler, R., & Berger, J. (2012, March). Human-mediated shifts in animal habitat use: Sequential changes in pronghorn use of a natural gas field in Greater Yellowstone. *Biological Conservation, 147*(1), 222-233.

Benton, T., Bieg, C., Harwatt, H., Pudasaini, R., & Wellesley, L. (2021). *Food system impacts on biodiversity loss: Three levers for food system transformation in support of nature.* Energy, Environment and Resources Programme, London.

Bunge. (2023, November 1). *Bunge Completes Move of Place of Incorporation to Switzerland, Declares Dividend*. Retrieved January 2025, from Bunge: https://investors.bunge.com/news-and-events/press-releases/2023/01-11-2023-132451677

Bunge. (2024). *2024 Global Sustainability Report.* Retrieved February 2025, from Bunge: https://delivery.bunge.com/-/media/Files/pdf/2024-Bunge-Global-Sustainability-Report.ashx

Bunge Global SA. (2024, February 22). *Form 10-k for the fiscal year ended December 31, 2023.* Retrieved January 2025, from Securities and Exchange Commission: https://www.sec.gov/ix?doc=/Archives/edgar/data/1996862/000199686224000007/bg-20231231.htm

Bunge. (n.d.). *Our 200+ Years History*. Retrieved January 2025, from Bunge: https://www.bunge.com/We-are-Bunge/Our-History

Bunge. (n.d.). *We are Bunge*. Retrieved January 2025, from https://www.bunge.com/We-are-Bunge

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., . . . Larig. (2012, June 7). Biodiversity loss and its impact on humanity. *Nature, 486*.

Center for Biological Diversity. (n.d.). *Save the Permian Basin's Endangered Species*. Retrieved January 2025, from Center for Biological Diversity: https://act.biologicaldiversity.org/komuHlk7gEC44KWIATHAxA2

Concha Larrauri, P., Lall, U., Siegel, J., & Arbarzua, F. (2019). *Risk-Based Water Valuation for Mining Companies*. Retrieved January 2025, from https://water.columbia.edu/content/risk-based-water-valuation-mining-companies

Convention on Wetlands. (2021). *WETLANDS AND BIODIVERSITY.* Retrieved January 2025, from Ramsar: https://www.ramsar.org/sites/default/files/ramsar_50_factsheet_biodiversity_english_as_v7.pdf

Cozim-Melges, F., Ripoll-Bosch, R., Veen, G., Oggiano, P., Bianchi, F., van der Putten, W., & Zanten, H. (2024, January 9). Farming practices to enhance biodiversity across biomes: a systematic review. *npj Biodiversity, 3*.

Dasgupta, P. (2021). *The Economics of Biodiversity: The Dasgupta Review. Abridged Version.* London: HM Treasury.

Diamondback Energy. (2024). *2024 Corporate Sustainability Report.* Retrieved January 2025, from https://www.diamondbackenergy.com/static-files/faf5ab25-5ab5-4404-8c04-c7bd387ae418

Diamondback Energy. (n.d.). *Investor FAQs*. Retrieved January 2025, from Diamondback Energy: https://ir.diamondbackenergy.com/investors/investor-faqs

Diamondback Energy, Inc. (2024, February 22). *Form 10-K for the fiscal year ended December 31, 2023.* Retrieved January 2025, from U.S. Securities and Exchange Commission: https://www.sec.gov/ix?doc=/Archives/edgar/data/1539838/000153983824000019/fang-20231231.htm

Díaz, S., Fargione, J., Chapin III, F., & Tilman, D. (2006). Biodiversity Loss Threatens Human Well-Being. *PLoS Biology, 4*(8).

Edmond, C. (2021, October 2021). *This is how oil spills damage our environment*. Retrieved January 2025, from World Economic Forum: https://www.weforum.org/stories/2021/10/oil-spill-environment-ocean/

Elanco. (2024, July). *Water Management and Biodiversity*. Retrieved January 2025, from Elanco: https://www.elanco.com/en-us/sustainability/esg-reporting/water-management-biodiversity

ENCORE. (n.d.). *Exploring Natural Capital Opportunities, Risks and Exposure*. Retrieved January 2025, from https://encorenature.org/en

Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS. (2021, April). Retrieved January 2025, from ArcGIS:

https://www.arcgis.com/apps/mapviewer/index.html?layers=6e90cefddb634e6a949838e7efff55fb&fbclid=IwZXh0bgNhZW0CMTEAAR1U4v31qQ2_YFNeiyrvii89D8JEN_WwE_tRKQ87BExjtb0ZU669MKy80gE_aem_fok0BNg-Ckwbi2xsOMOt8w

European Commission. (2024, May 17). *Biodiversity*. Retrieved January 2025, from Agriculture and rural development: https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/biodiversity_en

European Parliament. (2024, December 17). *Deforestation law: Parliament gives companies extra year to comply*. Retrieved January 2025, from https://www.europarl.europa.eu/news/en/press-room/20241212IPR25961/deforestation-law-parliament-gives-companies-extra-year-to-comply

Farwell, L. S., Wood, P. B., Dettmers, R., & Brittingham, M. C. (2020, April 27). Threshold responses of songbirds to forest loss and fragmentation across the Marcellus-Utica shale gas region. *Landscape Ecology, 35*, 1353-1370.

Finance for Biodiversity Foundation. (2023, April). *Briefing paper: Top 10 biodiversity-impact ranking of company industries.* Retrieved January 2025, from https://www.financeforbiodiversity.org/wp-content/uploads/Top10_biodiversity-impact_ranking.pdf

Fish and Wildlife Service. (2024). *Endangered and Threatened Wildlife and Plants; Endangered Species Status for the Dunes Sagebrush Lizard.* Federal Register, Department of the Interior. Washington, DC: Federal Register.

Fortune. (2024, June 4). *Alcoa*. Retrieved January 2025, from Fortune: https://fortune.com/company/alcoa/

Fortune. (2024, October 29). *Diamondback Energy*. Retrieved January 2025, from Fortune: https://fortune.com/company/diamondback-energy/

Fortune. (2024, August 4). *Fortune Global 500*. Retrieved January 2025, from Fortune: https://fortune.com/ranking/global500/

Giglio, S., Kuchler, T., Stroebel, J., & Zeng, X. (2023, May 11). *Biodiversity Risk.* Retrieved January 2025, from SSRN: https://download.ssrn.com/23/05/11/ssrn_id4445636_code5825574.pdf?response-content-disposition=inline&X-Amz-Security-Token=IQoJb3JpZ2luX2VjEMP%2F%2F%2F%2F%2F%2F%2F%2F%2F%2FwEaCXVzLWVhc3QtMSJIMEYCIQDiF3y5ubyYIZtSRQWT2ux9COPIF5uAhu6sVtV62J7UNgIhAKU%2F%2FfXm

Giglio, S., Kuchler, T., Stroebel, J., & Zeng, X. (2024, August 21). Biodiversity Risk. *biodiversityrisk.org*. Retrieved January 2025, from biodiversityrisk.org: biodiversityrisk.org

Giglio, S., Kuchler, T., Stroebel, J., & Zeng, X. (2024). *Download Data.* Retrieved January 2025, from Biodiversity Risk: https://www.biodiversityrisk.org/download/

Giglio, S., Kuchler, T., Stroebel, J., & Zeng, X. (n.d.). *Industry Exposures*. Retrieved January 2025, from biodiversityrisk.org: https://www.biodiversityrisk.org/exposures/

Harfoot, M., Tittensor, D., Knight, S., Arnell, A., Blyth, S., Brooks, S., . . . Burgess, N. (2018, March 14). Present and future biodiversity risks from fossil fuel exploitation. *Conservation Letters, A Journal of the Society for Conservation Biology, 11*.

International Finance Corporation. (2012, January 1). *Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources.* Retrieved February 2025, from International Finance Corporation: https://www.ifc.org/content/dam/ifc/doc/2010/2012-ifc-performance-standard-6-en.pdf

IPBES. (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.*

IUCN Red list. (n.d.). *The IUCN Red List of Threatened Species*. Retrieved January 2025, from IUCN Red List: https://www.iucnredlist.org/

Karolyi, G., & Tobin-de la Puente, J. (2023, February 13). Biodiversity finance: A call for research into financing nature. *Financial Management, 52*(2), 231-251.

Kenton (author), W., Scott (reviewer), G., & Kvilhaug (fact checker), S. (2024, June 18). *10-K: Definition, What's Included, Instructions, and Where to Find It*. Retrieved January 2025, from Investopedia: https://www.investopedia.com/terms/1/10-k.asp

Kiviat, E. (2013). Risks to biodiversity from hydraulic fracturing for natural gas in the Marcellus and Utica shales. *Annals of the New York Academy of Sciences, 1286*(1), 1-14.

Kurth, T., Wübbels, G., Portafaix, A., Felde, A. M., & Zielcke, S. (2021, March). *The Biodiversity Crisis Is a Business Crisis.* Retrieved January 2025, from https://web-assets.bcg.com/fb/5e/74af5531468e9c1d4dd5c9fc0bd7/bcg-the-biodiversity-crisis-is-a-business-crisis-mar-2021-rr.pdf

Maus, V., Giljum, S., Gutschlhofer, J., Da Silva, D., Probst, M., Gass, S., . . . McCallum, I. (2020, September 8). A global-scale data set of mining areas. *Scientific Data, 7*(1).

McAiley, N. (2024, May 21). *In Debate Over High Court Wording, 'Wetland' Remains Murky.* Retrieved January 2025, from Carlton Fields: https://www.carltonfields.com/insights/publications/2024/law360-mcaliley-in-debate-over-high-court-wording-wetland-remains-murky

Mining Plus. (2020, December 17). *S-K 1300: Under the new Regulations "Material" Properties Require Reporting...* Retrieved January 2025, from Mining Plus: https://www.mining-plus.com/post/s-k-1300-under-the-new-regulations-material-properties-require-reporting

MSCI. (2024, August). *GLOBAL INDUSTRY CLASSIFICATION STANDARD (GICS®) METHODOLOGY: Guiding Principles and Methodology for GICS.* Retrieved January 2025, from MSCI: https://www.msci.com/indexes/documents/methodology/0_MSCI_Global_Industry_Classification_Standard_GICS_Methodology_20240801.pdf

Natural Capital Finance Alliance and UN Environment World Conservation Monitoring Centre. (2018). *Exploring Natural Capital Opportunities, Risks and Exposure: A practical guide for financial institutions.* Retrieved January 2025, from https://encorenature.org/resources/exploring-natural-capital-opportunities-risks-and-exposure

Panwar, R., Ober, H., & Pinkse, J. (2022, May 30). The uncomfortable relationship between business and biodiversity: Advancing research on business strategies for biodiversity protection. *Business Strategy and the Environment, 32*(5), 2554-2566.

Sonter, L., Ali, S., & Watson, J. (2018, December 5). Mining and biodiversity: key issues and research needs in conservation science. *Proceedings of the Royal Society B*.

Sonter, L., Herrera, D., Barrett, D., Galford, G., Moran, C., & Soares-Filho, B. (2017). Mining drives extensive deforestation in the Brazilian Amazon. *Nature Communications*(8).

Texas Parks & Wildlife. (n.d.). *Trans-Pecos West Texas Habitat Wildlife Management Vegetation*. Retrieved January 2025, from Texas Parks & Wildlife: https://tpwd.texas.gov/landwater/land/habitats/trans_pecos/vegetation/

The Royal Society. (n.d.). *How do humans affect biodiversity?* Retrieved January 2025, from https://royalsociety.org/news-resources/projects/biodiversity/human-impact-on-

biodiversity/#:~:text=Key%20areas%20of%20human%20activity,that%20caused%20by%20urban%20sprawl
The Wetlands Initiative. (n.d.). *High Biodiversity*. Retrieved January 2025, from https://www.wetlands-initiative.org/high-biodiversity
Tortora, A. (2024, August 8). *CSRD and ESRS E4: your guide to biodiversity reporting*. Retrieved January 2025, from 3Bee: https://blog.3bee.com/en/csrd-and-esrs-e4-your-guide-to-biodiversity-reporting/#paragraph-32600
Ullenberg, B. (2024, May 17). *U.S. Fish and Wildlife Service Lists Dunes Sagebrush Lizard under the Endangered Species Act*. Retrieved January 2025, from U.S. Fish and Wildlife Service: https://www.fws.gov/press-release/2024-05/service-lists-dunes-sagebrush-lizard
UN Climate Change Conference UK 2021. (2021, November 2). *[Archived Content] Glasgow Leaders' Declaration on Forests and Land Use.* Retrieved January 2025, from The National Archives: https://webarchive.nationalarchives.gov.uk/ukgwa/20230418175226/https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use/
UN Environment Programme, U. F. (2020). *Beyond 'Business as Usual': Biodiversity targets and finance.* Cambridge: UNEP-WCMC.
United Nations. (n.d.). *Biodiversity - our strongest natural defense against climate change*. Retrieved January 2025, from United Nations: https://www.un.org/en/climatechange/science/climate-issues/biodiversity
USDA Climate Hubs. (n.d.). *Ecosystem Services*. Retrieved January 2025, from https://www.climatehubs.usda.gov/ecosystem-services
Warrior. (2023). *2023 Annual Report.* Retrieved January 2025, from Warrior Met Coal: https://investors.warriormetcoal.com/~/media/Files/W/Warrior-IR-V2/documents/annual-reports/warrior-2023-annual-report.pdf
Warrior. (2023). *Corporate Responsibility Report 2023.* Retrieved February 2025, from https://warriormetcoal.com/wp-content/uploads/2024/02/2023-Corporate-Responsibility-Report-ESG.pdf
Warrior Met Coal. (n.d.). *Warrior Met Coal Mining Operations*. Retrieved January 2025, from Warrior Met Coal: https://warriormetcoal.com/operations/#:~:text=Based%20out%20of%20Brookwood%2C%20Alabama,4%20and%20Mine%20No.
Warrior Met Coal, Inc. (2024, February 14). *Form 10-k for the fiscal year ended December 31, 2023.* Retrieved January 2025, from Securities and Exchange Commision: https://www.sec.gov/ix?doc=/Archives/edgar/data/1691303/000169130324000008/hcc-20231231.htm
Watson, R. (2021, October 29). *Loss of biodiversity is just as catastrophic as climate change*. Retrieved January 2025, from The Guardian: https://www.theguardian.com/commentisfree/2019/may/06/biodiversity-climate-change-mass-extinctions
World Bank Group. (2019, May 22). *Why the Amazon's Biodiversity is Critical for the Globe: An Interview with Thomas Lovejoy*. Retrieved January 2025, from World Bank: https://www.worldbank.org/en/news/feature/2019/05/22/why-the-amazons-biodiversity-is-critical-for-the-globe#:~:text=The%20Amazon's%20forest%20and%20rivers,is%20an%20important%20local%20staple.
World Economic Forum and PwC. (2022). *Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy.*

Yahoo Finance. (2025, January 31). *Ticker: AA via Yahoo Finance API*. Retrieved January 2025, from Yahoo Finance: https://pypi.org/project/yfinance/
Yahoo Finance. (2025, January 31). *Ticker: ADM via Yahoo Finance API*. Retrieved January 2025, from Yahoo Finance: https://pypi.org/project/yfinance/
Yahoo Finance. (2025, January 31). *Ticker: AR via Yahoo Finance API.* Retrieved January 2025, from https://pypi.org/project/yfinance/
Yahoo Finance. (2025, January 31). *Ticker: BG via Yahoo Finance API*. Retrieved January 2025, from https://pypi.org/project/yfinance/
Yahoo Finance. (2025, January 31). *Ticker: FANG via Yahoo Finance API.* Retrieved January 2025, from Yahoo Finance: https://pypi.org/project/yfinance/
Yahoo Finance. (2025, January 31). *Ticker: HCC via Yahoo Finance API*. Retrieved January 2025, from https://pypi.org/project/yfinance/

APPENDIX 1

BIODIVERSITY DICTIONARY TERMS IN FIRM 10-K STATEMENTS

This dictionary is found in the May 2023 version of *Biodiversity Risk* (Giglio, Kuchler, Stroebel, & Zeng, Biodiversity Risk, 2023). In the most recent version of *Biodiversity Risk*, the authors expand this dictionary to 100 terms (Giglio, Kuchler, Stroebel, & Zeng, Biodiversity Risk, 2024).

	Oil & Gas		**Metals & Mining**		**Agricultural Products**	
	Diamondback Energy	**Antero Resources**	**Alcoa**	**Warrior Met Coal**	**Archer-Daniels-Midland**	**Bunge Global**
biodiversity	-	P^	T	-	T, P^	-
ecosystem(s)	-	-	-	T*	-	-
ecology (ecological)	T	-	-	-	-	-
habitat(s)	T	T	T*	T*	P	-
species	T	T	-	T, T*	-	-
(rain)forest(s)	-	-	T	-	T	T
deforestation	-	-	T	-	T	T
fauna	-	-	T*	-	-	-
flora	-	-	-	-	-	-
marine	-	-	-	-	-	-
tropical	-	-	-	-	-	-
freshwater	-	-	-	-	-	-
wetland	T	T	-	T	-	-
wildlife	T	T	-	T	-	-
coral	-	-	-	-	-	-
aquatic	-	-	-	-	-	-
desertification	-	-	-	-	-	-
carbon sink(s)	-	-	-	-	-	-
ecosphere	-	-	-	-	-	-
biosphere	-	-	-	-	-	-

T = transition risk
P = physical risk
* = mentioned in SK 1300, not in 10-K
^ = open to interpretation. Not an explicit mention of risk.

APPENDIX 2

SUMMARY OF BIODIVERSITY RISKS DISCUSSED BY OIL & GAS FIRMS

	Diamondback Energy	Antero Resources
Company facts		
Market capitalisation (as of January 31, 2025)	$48.6 billion	$12.47 billion
Headquarters	Midland, Texas	Denver, Colorado
Nature of operations	Oil & natural gas exploration	Oil & natural gas exploration
Geography of operations	Permian Basin, West Texas	Marcellus & Utica shales, Appalachian Basin, East United States
Biodiversity risk discussed in 2023 10-K		
General environmental matters	More stringent pollution control regulations ➔ material & adverse effects on operations & financial position	Compliance with existing or amended regulations ➔ material adverse impact on financial position, results of operations or cash flows
Wetlands	Change in scope of waters covered by Clean Water Act to include wetlands ➔ increased costs & delays to obtain dredge & fill permits	• Change in scope of waters covered by Clean Water Act to include wetlands ➔ increased costs & delays to obtain dredge & fill permits ➔ impact on ability to transport products • Requirement for spill prevention, control & countermeasure plans ➔ liability for removal, remediation & damages
Endangered species & habitats	• Endangered species located in area of operations ➔ operations prohibited, delayed, or requiring expensive mitigation • Previously unprotected species living in area of operations designated as threatened or endangered ➔ restrictions on operations • Seasonal restrictions imposed relating to protected habitats ➔ limit ability to operate & increase competition in permitted operating periods	• Area of operations designated as critical or suitable habitat for threatened or endangered species ➔ delay or prohibit operations, or adversely impact value of leases • Previously unprotected species living in area of operations designated as threatened or endangered ➔ increased cost for species protection or limitations on operations • Seasonal restrictions imposed relating to protected habitats ➔
To-date material adverse effect from biodiversity risk	None	None
Biodiversity risk mitigation strategies	• New sites: endangered species assessments & working with third parties to minimise impacts • Voluntary Candidate Conservation Agreement with Assurances for protection of dunes sagebrush lizard	• Integration of biodiversity protection in operations, according to International Finance Corporate's mitigation hierarchy • Current evaluation of Taskforce on Nature-Related Financial Disclosures for opportunities to exceed regulatory compliance

APPENDIX 3

SUMMARY OF BIODIVERSITY RISKS DISCUSSED BY METALS & MINING FIRMS

	Alcoa	Warrior Met Coal
Company facts		
Market capitalisation (as of January 31, 2025)	$9.33 billion	$2.79 billion
Headquarters	Pittsburgh, Pennsylvania	Brookwood, Alabama
Nature of operations	Mining, refining, smelting & casting aluminum products	Mining metallurgical coal
Geography of operations	Multiple sites in Australia, Brazil, Canada, Iceland, Norway, Spain & the US (plus joint ventures in Guinea & Saudi Arabia)	Alabama
Biodiversity risks discussed in 2023 10-K		
General biodiversity regulations	Delayed, rescinded or modified permits ➔ material adverse on operations or profitability	Compliance with regulations ➔ increased costs, and/or delayed or interrupted operations, and/or impact on customers' ability to use products
Deforestation regulations	Regulations resulting from COP26 ➔ impact company competitiveness, and/or attractiveness of company asset locations	No mention
Species protection	N/A	• Species protection at sites of operations and/or designation of previously unprotected species as threatened or endangered ➔ prohibit or delay operations, and/or incur additional costs • Cost of compliance ➔ impact competitiveness with firms outside North America
To-date material adverse effect from biodiversity risk	• Delayed obtaining of mine permit in Western Australia ➔ mined lower grade bauxite ➔ decreased alumina output • New biodiversity & forest rehabilitation (among other) requirements in Western Australia ➔ $40 million cash spend over next 3.5 years	No mention
Biodiversity risk mitigation strategies	• Biodiversity Action Plan for each operational site • New Center of Excellence for Biodiversity • 2023 review of biodiversity risk assessments and intention to report in line with Taskforce on Nature-related Financial Disclosures by the end of 2025 • Commitment to work toward no net loss of biodiversity	• Collaboration with regulatory bodies on environmental studies • Specific projects to go beyond compliance, including wetland development

APPENDIX 4

SUMMARY OF BIODIVERSITY RISKS DISCUSSED BY AGRICULTURAL PRODUCTS FIRMS

	Archer-Daniels-Midland	**Bunge Global SA**
Company facts		
Market capitalisation (as of January 31, 2025)	$24.66 billion	$10.77 billion
Headquarters	Chicago, Illinois	• Operational HQ: St Louis, Missouri • Registered office: Geneva, Switzerland
Nature of operations	• Trading & processing agricultural commodities, primarily oilseeds & grains • Manufacturing food products for humans & animals	• Trading & processing agricultural commodities, primarily oilseeds & grains • Manufacturing food products for humans & animals
Geography of operations	150+ countries, 6 continents	40+ countries, 6 continents
Biodiversity risks discussed in 2023 10-K		
Physical risk	Protection of habitats & biodiversity is important to ADM business	No mention
General environmental regulation	N/A	Imposition of regulatory restriction in many markets ➔ affect land-use decisions, cost of production, cost & means of transport ➔ adversely affect business, cashflows & results of operations
Deforestation regulations, including EU Deforestation Regulation (EUDR)	• Failure to comply ➔ civil, administrative, & criminal penalties, & negative impact on reputation, business, cash flows, & results of operations	Compliance ➔ increased costs, & investment to modify operations
Monitoring & reporting	• Implementation of monitoring & reporting ➔ increased costs & reporting risk • Failure to comply ➔ civil, administrative, & criminal penalties, & negative impact on reputation, business, cash flows, & results of operations	No mention
Reputational risk	Mentioned in context of deforestation, & monitoring & reporting	(Perceived) failure to meet expectations of environmental responsibility ➔ reduced demand, disruption to operations, &/or loss of market share
To-date material adverse effect from biodiversity risk	No mention	None
Biodiversity risk mitigation strategies	• 16 biodiversity-related goals, including 100% deforestation-free across all supply chains and 100% deforestation-free soy by the end of 2025 ➔ mitigate EUDR risks	• 100% deforestation-free commitment by the end of 2025 ➔ mitigate EUDR risks • Early adoption of Taskforce on Nature-related Financial Disclosures LEAP framework for reporting and governance ➔ mitigate reputational risks

APPENDIX 5

INDUSTRY SELECTION PROCESS

5 industries most exposed to biodiversity risk (Giglio, Kuchler, Stroebel, & Zeng, 2024)	**9 sub-industries most likely exposed to biodiversity risk** (UN Environment Programme, 2020)	**Selection for this paper**
Energy (1010)	Oil & Gas Exploration & Production (10102020) Oil & Gas Storage & Transportation (10102040)	Oil & Gas (101020)
Utilities (5510)	Electric Utilities (551010) Independent Power Producers & Energy Traders (551050)	N/A
Food, Beverage & Tobacco (3020)	Agricultural Products (30202010) Brewers (30201010)	Agricultural Products (30202010)
Pharmaceuticals, Biotech & Life Sciences (3520)	N/A	N/A
Materials (1510)	(Metals &) Mining (151040)	Metals & Mining (151040)
N/A	Apparel, Accessories & Luxury Goods (252030)	N/A
N/A	Distribution (255010)	N/A

APPENDIX 6

FIRM MARKET CAPITALISATIONS

Screenshots from Jupyter notebook on Google Colab.

Market capitalisations result from calls to the Yahoo Finance API[19] on January 31, 2025.

OIL & GAS

index	ticker	year	cusip	bio_mention	bio_negative	bio_regulation	gvkey	company_name	gics	naics	market_cap
4422	FANG	2023	25278X109	1.0	1	1.0	170750.0	DIAMONDBACK ENERGY INC	10102020	2111	48639524864.0
493	AR	2023	03674X106	1.0	1	1.0	18465.0	ANTERO RESOURCES CORP	10102020	2111	11698210816.0
3773	DTM	2023	23345M107	1.0	1	1.0	39041.0	DT MIDSTREAM INC	10102040	486210	10391891968.0
5361	HESM	2023	428103105	1.0	1	1.0	21833.0	HESS MIDSTREAM LP	10102040	211130	9060038656.0
7473	MTDR	2023	576485205	1.0	2	1.0	187812.0	MATADOR RESOURCES CO	10102020	2111	7342891008.0
2175	CHRD	2023	674215207	1.0	1	1.0	184442.0	CHORD ENERGY CORP	10102020	2111	6968265728.0
10455	SM	2023	78454L100	1.0	3	1.0	26013.0	SM ENERGY CO	10102020	2111	4452004352.0
2007	CEIX	2023	20854L108	1.0	1	1.0	32372.0	CONSOL ENERGY INC	10102050	212115	2927986176.0
5488	HPK	2023	43114Q105	1.0	1	1.0	36897.0	HIGHPEAK ENERGY INC	10102020	2111	1751223680.0
9369	REPX	2023	76665T102	1.0	1	1.0	34183.0	RILEY EXPL PERMIAN INC	10102020	211120	725692352.0
340	AMPY	2023	03212B103	1.0	1	1.0	194755.0	AMPLIFY ENERGY CORP	10102020	211120	217683344.0
2955	CPE	2023	13123X508	1.0	1	1.0	15060.0	CALLON PETROLEUM CO/DE	10102020	2111	NaN
4272	ETRN	2023	294600101	1.0	3	1.0	34337.0	EQUITRANS MID CORP	10102040	486210	NaN
9817	SBOW	2023	82836G102	1.0	1	1.0	10221.0	SILVERBOW RESOURCES INC	10102020	211130	NaN
10918	SWN	2023	845467109	1.0	1	1.0	9904.0	SOUTHWESTERN ENERGY CO	10102020	2111	NaN

METALS & MINING

index	ticker	year	cusip	bio_mention	bio_negative	bio_regulation	gvkey	company_name	gics	naics	market_cap
0	AA	2023	013872106	1.0	2	1.0	27638.0	ALCOA CORP	15104010	331313	9331782656
5306	HCC	2023	93627C101	1.0	1	1.0	30397.0	WARRIOR MET COAL INC	15104050	21211	2796049664
672	ARCH	2023	03940R107	1.0	1	1.0	14793.0	ARCH RESOURCES INC	15104050	21211	2441623040

AGRICULTURAL PRODUCTS

index	gvkey	conm	fyear	tic	cusip	cik	sic	gsubind	naics	permno	market_cap
1802	1722	ARCHER-DANIELS-MIDLAND CO	2023	ADM	039483102	0000007084	2070	30202010	31122	10516	24658857984
101999	144435	BUNGE GLOBAL SA	2023	BG	H11356104	0001996862	2040	30202010	311211	89138	10770827264
85285	66016	INGREDION INC	2023	INGR	457187102	0001046257	2040	30202010	311221	85645	8931804160
62023	30651	DARLING INGREDIENTS INC	2023	DAR	237266101	0000916540	2070	30202010	311613	80928	6054957056
61420	30443	FRESH DEL MONTE PRODUCE INC	2023	FDP	G36738105	0001047340	0100	30202010	111339	85449	1480925312
123678	201336	CRESUD SOCIEDAD ANONIMA COM	2023	CRESY	226406106	0001034957	9997	30202010	999977	84603	858012864
60148	29962	LIMONEIRA CO	2023	LMNR	532746104	0001342423	0100	30202010	111320	93397	420612896
126253	277487	BRASILAGRO CIA BRAS DE PROP	2023	LND	10554B104	0001499849	0100	30202010	111	13680	387006240
672	1266	ALICO INC	2023	ALCO	016230104	0000003545	0100	30202010	111310	11790	239851792
106201	157875	VILLAGE FARMS INTL INC	2023	VFF	92707Y108	0001584549	0100	30202010	111219	18416	79781736
120395	184259	S&W SEED CO	2023	SANW	785135104	0001477246	0100	30202010	111998	93434	18926988
69435	37856	LOCAL BOUNTI CORP	2023	LOCL	53960E205	0001840780	0100	30202010	111	20999	18852050
70832	39783	BENSON HILL INC	2023	BHIL	082490202	0001830210	0100	30202010	111	20552	14734789
67964	35967	SADOT GROUP INC	2023	SDOT	627333107	0001701756	0100	30202010	1111	19233	14296984
111428	165510	ORIGIN AGRITECH LTD	2023	SEED	G67828205	0001321851	0100	30202010	111150	90976	14285077
45383	23098	ARCADIA BIOSCIENCES INC	2023	RKDA	039014303	0001469443	0100	30202010	111	15382	7033263
71024	40016	EDIBLE GARDEN AG INC	2023	EDBL	28059P303	0001809750	0100	30202010	111419	23109	6880318
69167	37547	AGRIFORCE GROWING SYSTEM LTD	2023	AGRI	C00948122	0001826397	0700	30202010	115	21698	3658707
69613	38240	AFRICAN AGRICLTRE HLDNGS INC	2023	AAGR	00792J100	0001848898	0100	30202010	111998	22253	462935

[19] https://pypi.org/project/yfinance/

APPENDIX 7

ALCOA SITES OF OPERATIONS

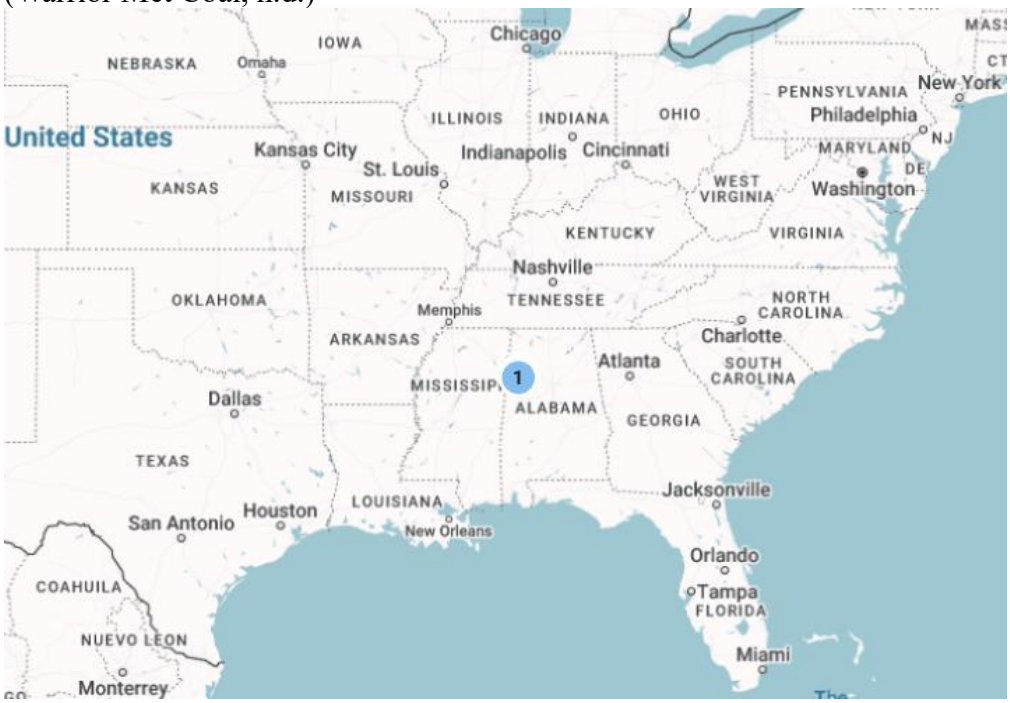
(Alcoa, 2023)

APPENDIX 8

WARRIOR MET COAL SITES OF OPERATIONS AND IMPERILLED SPECIES RICHNESS

MAP OF WARRIOR MET COAL OPERATIONS

(Warrior Met Coal, n.d.)



MAP OF RICHNESS OF IMPERILLED SPECIES

(Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS, 2021)